# District Heating and Cooling Program Policy Analysis

## Appendix
## Case Summaries

Prepared for

Assistant Secretary for
Community Planning and Development
Department of Housing and
Urban Development

April, 1985

APPENDIX

DHC SYSTEM CASE SUMMARIES

APPENDIX

This appendix presents case summaries or several case studies of successful district heating system programs.

° St. Paul, Minnesota

° Piqua, Ohio

° Provo, Utah

° Baltimore, Maryland

° Lawrence, Massachusetts

° Jamestown, New York

Of the six, first phases have been built and are operating systems in four -St. Paul, Minnesota; Lawrence, Massachusetts; Piqua, Ohio; and Jamestown, New York. Provo is in the final design/bid phase and will start construction in spring, 1985. Baltimore is in the final stages of negotiation for the line between the MSW plant and Cherry Hill. Both the MSW plant and the Cherry Hill distribution system are moving forward.

These cases are instructive in identifying how and why systems are developed. In each case certain conditions are present to a greater or lesser degree that facilitate project success. The basic conditions necessary are as follows.

1. Technically competent and opportunistic project development team.
2. Finding support for project planning and packaging sufficient to provide "staying power".
3. Committed community leadership.
4. Long-term financial benefit to both suppliers and users of energy.
5. Sound development planning using a staged development approach.

Each of these systems followed divergent routes to success, but in each case, these conditions were present.

These cases were developed by persons directly involved in each project, and present the author's viewpoint of the project. RDA presents capsule analysis of each identifying highlights and reasons for success. Additional case studies were prepared and are avialable upon request.

# DISTRICT HEATING AND COOLING DEVELOPMENT IN ST. PAUL, MINNESOTA

## A CASE SUMMARY

Excerpt in part from a report by:

Hans Nyman
Director, St. Paul District Heating Company

St. Paul, Minnesota

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The advent of the oil crisis in 1973-74 led to a resurgence of interest and development in district heating. In the mid-1970s the U.S. Department of Energy (DOE) and the Minnesota Energy Agency (MEA) initiated a study to determine the feasibility of a modern hot water district heating system for a U.S. city. The idea for such a study was the result of the large number of successful systems designed and built in northern Europe over the past 25 years. Many of the systems serve large segments of a city; several of them serve single-family residential consumers. Based on the success of the European systems, these studies were initiated to evaluate the European concept as it applied to a northern U.S. city.

The Minneapolis-St. Paul area was chosen as the site because it met the technical criteria, such as high number of heating degree days (8000° F), large potential load, and the potential for a variety of energy sources. The object of the study was to outline the general features of a new Twin Cities-wide hjot water district heating system, assumed to develop over a 20-year period. An encouraging overall feasibility study, along with other studies, resulted in the recommendation of St. Paul as the site for a closer project study.

As a result, DHDC was incorporated in July 1979 as a non-profit company by the Mayor of St. Paul, the Executive Director of the St. Paul Building Owners and Managers Association (BOMA), and the Director of the Minnesota Energy Agency (MEA). From mid-1979 to the end of 1980 constituted the study phase of the St. Paul project. One of the goals was to assess a preliminary economic feasibility of a hot water district heating system serving the commercial core area of St. Paul. Given preliminary economic feasibility, the idea was to market the system, prepare the final design and bid specification, and obtain firm bids. DHDC's financial advisor recommended that firm bids be obtained to receive the highest rating on the bond issue.

The final economic feasibility study was completed in September of 1982 and financing arranged in December of the same year. Construction of the project was originally based on a three-year time schedule. After the first year of successful construction it was decided to expedite the project and complete the construction in two years.

The St. Paul hot water district heating system has the potential to offer consumers many major advantages over operating their own building boilers:

- competitive space heating energy costs;
- lower maintenance costs and higher reliability;
- improved air quality in the community;
- improved safety (compared with fossil fuel-fired systems);
- smaller space requirements; and
- lower initial capital costs for new buildings.

Of these advantages, the most important to the consumer is the cost of the heat energy. In numerous U.S. cities, natural gas is the alternative to district heating. The main feature that makes a district heating system competitive is its fuel flexibility which implies the use of comparatively inexpensive fuels such as coal.

The initail project cost, including construction, financing, and other expenses, but not building conversion, is $45.8 million. The cost has been financed as follows:

| | |
|---|---|
| Tax exempt revenue bonds | $30.50 million |
| City/HUD-UDAG Loan | 9.80 |
| City equity loan | 5.50 |
| | $45.80 million |

The funds will be used as follows:

| | |
|---|---|
| Piping construction | $24.51 million |
| Heat source modifications (Third Street Plant and St. Paul Ramsey Medical Center) | 6.64 |
| Mobile boilers, meters and service equipment | .74 |
| Misc. costs including insurance, initial operating losses, and capital improvements | 13.91 |
| | $45.80 million |

Customer heating system conversion costs in the initial system total approximately $22 million in 1982 dollars. Low interest loans to finance conversion costs are available to building owners from the St. Paul Port Authority. In addition, a consortium of foundation and corporate contributors is providing supplemental funding for non-profit organizations which sign up for district heating service.

## SUMMARY

The first year of DHDC's construction program is now complete. Twenty-two customers totaling 37 MW of thermal demand have installed new heat exchangers and converted their building heating systems to be compatible with the hot water provided by DHDC. With few exceptions the construction of the district heating piping has generally proceeded as orignially planned. The construction is ahead of schedule, and the project will be finalized in two years instead of the original three. When compared to the marketing and financing of the system, the technical engineering problems seem relatively minor.

The St. Paul project is largest and most ambitious of the modern, multi-sectoral district heating developments. Inspite of the success of this project, it is unlikely that circumstances will permit quick replication in other cities. Even though, it is instructive to note the circumstances that permitted the development of the system.

1. Northern States Power, the utility which owned the St. Paul steam system activity supported the project, and sold facilities to DHDC at a reasonable price.

2. The Mayor of St. Paul - George Latimer, a strong and highly visible proponent of energy conservation and district heating-provided active support throughout the project.

3. The project had the support of building owners and managers from the onset.

4. The State of Minnesota has a very positive attitude toward district heating systems and development.

5. The project received substantial funding from government which allowed the project developers the time and resources to overcome financial and institutional obstacles.

6. The project was able to secure an Urban Development Action Grant with favorable terms that allows the project to begin loan repayment once it has had time to stabilize itself financially.

These factors coupled with a sound technical program and good project management created the circumstances that permitted the St. Paul project to proceed. Although it is unlikely that another project can assemble all of these factors, each future project should recognize that the development path followed by DHDC is similar in nature, if not scope.

# DISTRICT HEATING AND COOLING DEVELOPMENT IN PIQUA, OHIO

## A CASE SUMMARY

Excerpt in part from a report by:

Piqua Municipal Power System

Piqua, Ohio

PIQUA, OHIO--CASE SUMMARY DISTRICT HEATING PROJECT

On December 6, 1982, the Piqua City Commission unanimously, on the recommendation of the Piqua Energy Board and the City administration, approved the development of a modern hot water district heating system. The system developed is owned and operated by the City of Piqua is the first phase of a multi-phase district energy system designed to provide thermal energy to industrial, commercial, and residential energy customers in Piqua, Ohio.

Piqua's implementation of how water district heating caps a process begun in 1978 to establish the feasibility of district heating and cogeneration through retrofit of the power plant. The Preliminary and Detailed Feasibility Analysis conducted by the City and Resource Development Associates, Inc. was sponsored by the Piqua and the U.S. Department of Energy, Community Systems Division, under the demonstration program titled "District Heating and Cooling for Communities Through Power Plant Retrofit and Distribution Network".

Throughout the planning and feasibility analysis the Piqua City Commission and other community leaders were involved and in fact participated in the planning, evaluation and implementation activities. The following points illustrate the City Commission's role and position regarding district heating and cogeneration.

- City Commission involved their local Piqua Energy Board, development corporations, and community leaders.

- The City Commission stressed the linkage between energy, the City-owned power system, and the City's long-term economic development strategy.

- The City Commission's decision reflects a philosophy of planned system expansion beginning now and proceeding through the decade.

- The City Commission determined that both thermal and electrical customers will benefit during the life of the project.

Project Configuration Growth and Phasing

The Piqua District Heating System is being implemented in planned phases which pace the required capital investment to thermal market growth. Importantly however, the Phase I, initial hot water system thermal requirements are supplied by the Piqua Municipal Power System, a coal-fired power plant. This allows the PMPS system and customers to immediately capture the economic benefits of both coal and cogeneration.

Phase I provides district heating service to new and existing customers within the City's Riverside Industrial Park. The initial phase consists of both in-plant modifications and a distribution system sized to allow additional district heating and industrial development. The installation of the hot water district heating system avoids expansion of steam service in the area and is consistent with Piqua's overall district heating development plan. The first phase of the project provides thermal energy for a new manufacturer and a hyroponic greenhouse. Both facilities are located in Riverside Industrial Park, an area acquired and developed through CDBG grants from the U.S. Department of Housing and Urban Development Small Cities Community Development Block Grant Program. The DH system is designed to accommodate growth within the Riverside Industrial Park and provides sufficient transmission line capacity for future expansion to a new industrial park immediately to the south. The in-plant modifications accomplished during

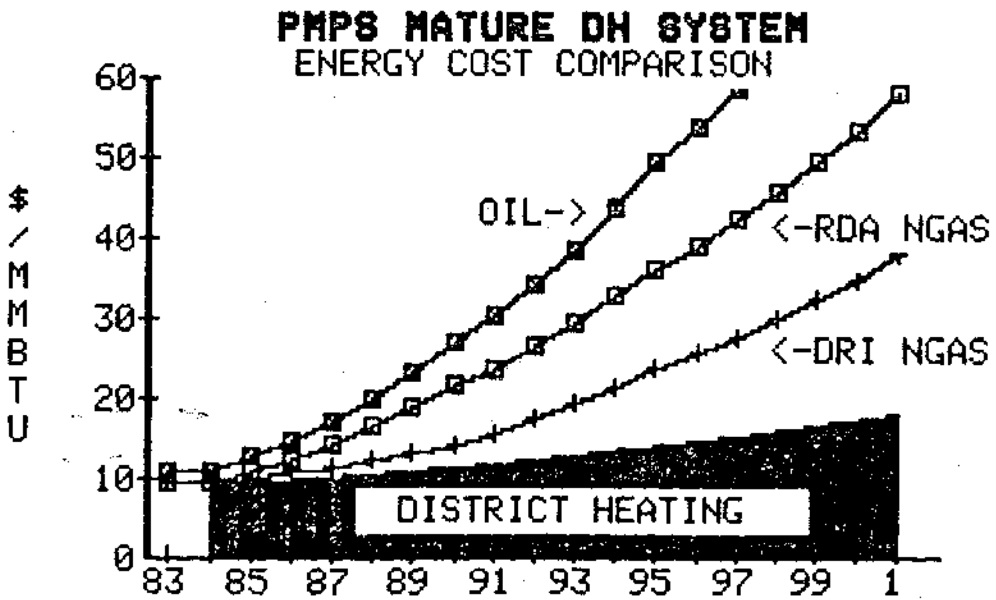
Phase I will also accommodate the district heating system's expansion to the existing industrial and commercial area north and west of the power plant. The following characterize and describe the Phase I District Heating Project.

1. Back Pressure Turbine/Generator .................. $ 325,000
2. Initial district heating piping system, in-plant modifications, heat exchangers and controls ....... $ 900,000
3. Sewer and water lines ............................ $ 500,000

TOTAL $1,725,000

Concurrent with the above district heating work, the PMPS must complete installation of 4 million dollars of air quality control equipment in the power plant. The distribution piping portion of the project was competitively bid based on performance specifications. Construction commenced 5/23/83 and was completed by 9/30/83.

The graph below illustrates the cost advantages accruing to customers connection to Piqua's coal-fired, cogeneration based district heating system.



FINANCED AT 12% FOR 20 YEARS
COGEN BENIFIT TO KWH CUSTOMER
INCLUDES ALL RETROFIT COST

The City of Piqua planning Phase II efforts--expansion of hot water district heating system to serve the industrial/commercial area north and west of the Power Plant. Analysis to date indicates that both existing thermal customers and the PMPS will benefit by replacement of the old steam system with a modern hot water thermal distribution network. Phase I has been designed to accommodate orderly growth of the district heating system. During 1983 and 1984 market development within the Phase II service area will continue. This will include refining distribution system and end-user retrofit cost estimates and finalizing expansion plans.

Phase II will serve low and moderate income housing Current plans call for the Phase II expansion to begin implementation in 1985 including phase out of the steam system and the retrofit of existing end-users, and the specification of a new, nominal 30MW cogeneration turbine generator.

<u>Summary</u>

The project in Piqua, Ohio has been successful to this point for a number of reasons including Piqua's ability to coordinate programmatic missions, i.e., the redevelopment of the Riverside Industrial Park using CDBG funds; the realization of the City Commission and PMPS management that they were in the business of supplying energy to the community not just electricity; and the realization that by coordinating energy, industrial development, and other local efforts, the outcome of each of these programs could be enhanced.

Piqua was fortunate to have the flexibility to seize the opportunity, and the support of the federal government (DOE and HUD) providing "staying power" necessary to take advantage of the development opportunities.

Piqua, like other early district heating study cities, started out with a grandiose scheme to provide thermal energy throughout the majority of the community. Piqua realized that such a scheme would be beyond the resources of the city. Piqua then moved to identify system development opportunities that were within the city's means. It was this shift that allowed Piqua to be successful. Similar development patterns are now being followed by other cities, notably Jamestown, New York, and Provo, Utah.

DISTRICT HEATING AND COOLING DEVELOPMENT IN

BALTIMORE, MARYLAND

A CASE SUMMARY

Excerpt in part from a report by:

Michael Gagliardo
North East Maryland Waste Disposal Authority

Baltimore, Maryland

The City of Baltimore has had a district heating system in the downtown business area since the early 1900's. Since 1978, the system, owned and operated by the Baltimore Gas and Electric Company (BG&E), has had approximately 600 customers. A moratorium on new customers was instituted at that time. Unfortunately, this was also a time of rapid and extensive redevelopment of the Inner Harbor area. The customer moratorium instituted by BG&E forced this new development to make investment in individual heating and cooling facilities and many potential customers for the steam system were lost. For a variety of reasons, including highly seasonal steam sales, reliance on expensive natural gas and fuel oil and no provision for condensate return, BG&E began looking for ways to leave the district heating business.

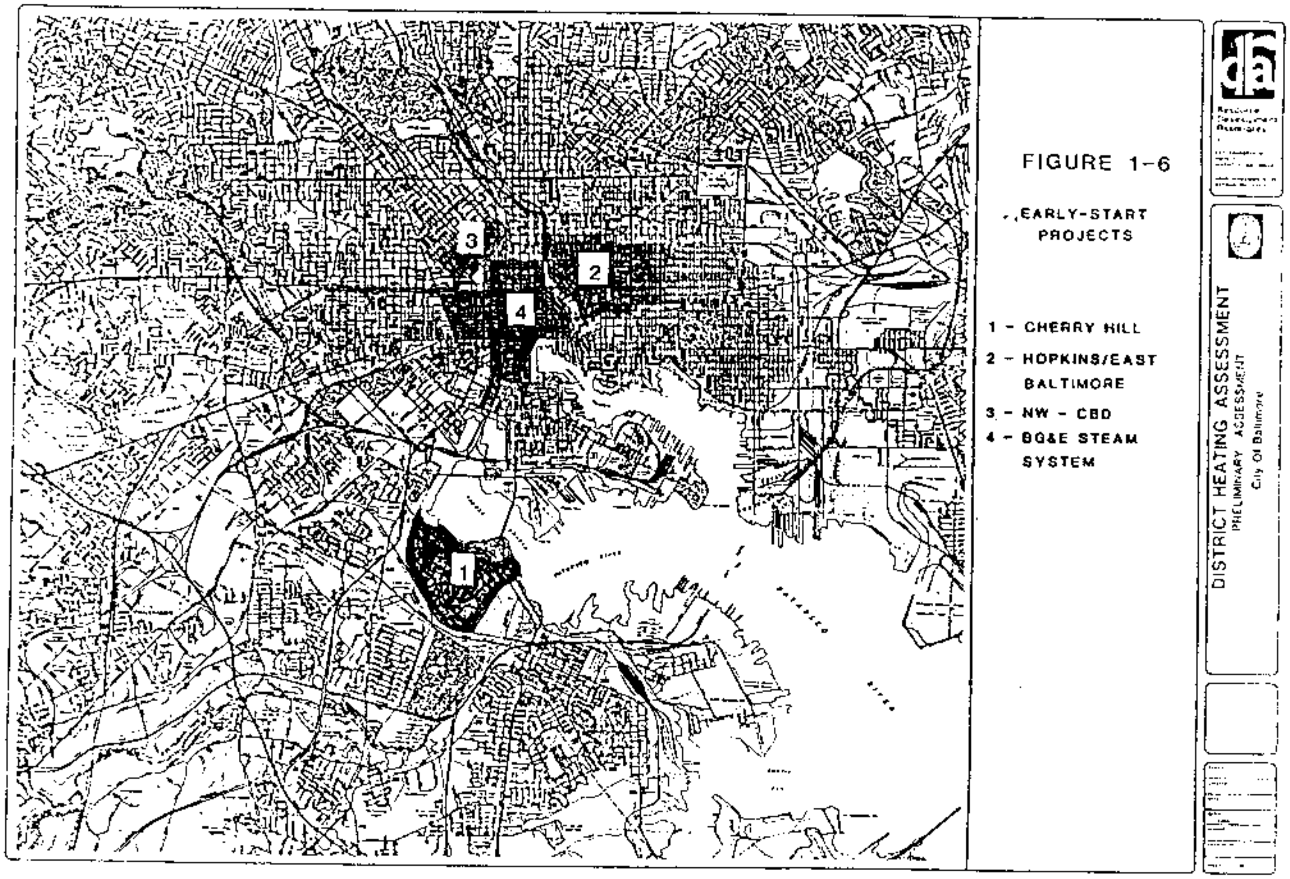
In 1973, BG&E executed a contract for steam purchase from the Baltimore City Pyrolysis Plant. Steam, produced from the processing of solid waste, was purchased and used in the downtown system. This arrangement could have been beneficial to the downtown system, providing a source of energy based on a plentiful and renewable fuel; however, the Pyrolysis Plant was very unreliable and finally closed permanently in 1981. It is difficult to determine the impact of a reliable Pyrolysis Plant on BG&E's decision to leave the steam business. However, it is likely that a reliable source of "baseload" steam produced from solid waste would have made the system much more economically attractive to potential customers.

In 1980, the decision was made to replace the Pyrolysis Plant with a larger, more reliable waste-to-energy facility, utilizing the same site. As would be expected, the Authority contacted BG&E concerning energy sales, with the hope of renegotiating and/or reinstating the steam sale agreement which had been in effect during the years of the Pyrolysis Plant's operation.

Unfortunately, since BG&E was interested in leaving the steam business, it could not offer a thermal energy price which would provide an acceptable waste disposal fee to the users of the facility. Project economics were more favorable to the Subdivisions if the facility was to produce electricity for sale. Due to the need to develop additional waste disposal capacity in the region, other options, such as Authority purchase of the downtown district heating system from BG&E or developing other potential thermal markets, were not explored in detail. At the time the implementation of a waste disposal facility was the overriding concern of the Authority and local governments. However, it was the Authority's feeling that the opportunity for thermal energy sales was viable and the projects contractual structure was set up in such a way to allow the inclusion of thermal sales at a later date.

## PROJECT IDENTIFICATION

As one of the original "twenty-eight cities" in the Department of Housing and Urban Development's (HUD) District Heating and Cooling Assessment Program, Baltimore began to look at district heating and cooling opportunities in 1981. Under the direction of the City Department of Planning, a panel of agencies interested in district heating identified several "early start" district heating systems, which would provide a basis for expansion and development of district heating in Baltimore. These systems involve large institutional users which would act as "anchor" customers. Projects, either directly or indirectly, included the Southwest Facility as a thermal source.




The Cherry Hill System involved the sale of medium temperature hot water (250-280° F) directly from the Southwest Facility to a variety of users in the Cherry Hill and Westport areas of South Baltimore. The anchor customer identified is the over 1600 unit Cherry Hill Homes and C. K. Anderson Public Housing projects (collectively referred to as the Cherry Hill Homes) operated by the Housing Authority of Baltimore City (HABC). In addition, six public schools, the South Baltimore General Hospital, private housing and a proposed industrial park are potential customers.

The Hopkins/East Baltimore System would involve either an expansion of the existing BG&E downtown system or the construction of a new thermal energy source and distribution system. This is an area adjacent to the downtown business district and the anchor customer identified is the over 2,000 units of public housing which make up the Central Avenue Housing Project, the Johns Hopkins Hospital, and two penal institutions (the Baltimore City Jail and the Maryland State Penitentiary). The U. S. Post Office, public schools, very dense private housing and other public housing offer additional opportunities. In this case, a steam system would be used from either a new thermal facility or an extension of the BG&E system. Steam from the Southwest Facility would be "wheeled" through the BG&E system to supply customer needs.

In August, 1982, Baltimore applied for and subsequently received one of the original HUD Phase II Assistance Awards to continue development of district heating opportunities identified under the original program. Due to the considerable institutional and technical complexity of the Hopkins/East Baltimore System, the City and its Project Team decide to concentrate efforts on the implementation of the Cherry Hill System and to refine the Hopkins/East Baltimore project concept with an eye toward future implementation.

PROJECT TEAM ORGANIZATION

As in the implementation of a resource recovery facility, there are certain factors which must be present to successfully implement a district heating system. In Baltimore, many of the key factors were present in Cherry Hill. HABC had been experiencing heating difficulties (due to an old, leaking steam distribution system) in Cherry Hill, and was exploring ways to correct the situation. Baltimore RESCO and the Authority were looking for markets for excess thermal energy being produced by the Southwest Facility and Baltimore City was interested in promoting district heating as a way to encourage development and improve the quality of services to institutional facilities in the City. In addition, the Authority and Baltimore RESCO, through the Southwest Facility project structure, represented a convenient institutional approach for development, financing and operation of such a system.

Key decisions were made by the two primary project participants, HABC and Baltimore RESCO, early in the development of the system. These decisions were supported by the technical, economic and financial experts within each organization and by the Project Team. HABC made the decision to replace the Cherry Hill Homes steam distribution and in-building heating system with a hot water system and to renovate the existing oil-fired central boiler plant. Baltimore RESCO decided to install an extraction turbine at the Southwest Facility which could provide hot water at the appropriate temperature and in the appropriate quantity to supply energy to the potential customers identified in Cherry Hill. With the two major project participants (the thermal energy source and the anchor customer) moving toward implementation, the role of the Project Team is to assist in structuring a "business deal" which would provide an acceptable amount of benefit to each party. The parties sharing in the benefit of the Cherry Hill System are the HABC, Baltimore Resco and the Subdivisions who dispose of waste at the Southwest Facility.

In order to implement the Cherry Hill project, the Authority organized multi-disciplinary teams to work on the various tasks which related to the implementation of the project. This approach worked well in the implementation of the Southwest Facility and has been used successfully in other Authority projects. A number of working groups were set up consisting of Project Team members, each responsible to the Project Manager for completion of specific tasks. The initial working group set up was a technical/economic group (consisting of Resource Development Associates (RDA), the Authority and the City) to work with Baltimore RESCO in developing the specifications for the extraction turbine and energy delivery conditions, developing a pricing structure and to work with HABC to conduct an "options assessment" which explored the available options (including individual gas boilers and renovating the existing steam distribution system) for correcting heating problems in Cherry Hill. A technical/engineering group was set up (consisting of RDA, Baltimore RESCO and Rust International) to develop the routing and size of the thermal transmission line, refine the estimates of thermal load and identify all potential customers along the route. A group to explore the legal/institutional issues (consisting of Piper & Marbury, RDA, the Authority and the City was established. This group identified all regulatory aspects of the proposed project (taxes, right-of-way, franchise, Public Service Commission regulation, etc.). In addition, this group investigated how the Cherry Hill System would be incorporated into the Southwest Facility contract structure. A sub-group of this working group met with HABC and Baltimore RESCO to begin negotiating terms of the "Thermal Energy Purchase Agreement," which would be the major legal document identifying the project participants' roles and responsibilities. These groups would continue in existence throughout the project. The level of effort and involvement of various Project Team members would vary according to the specific needs of the task at hand.

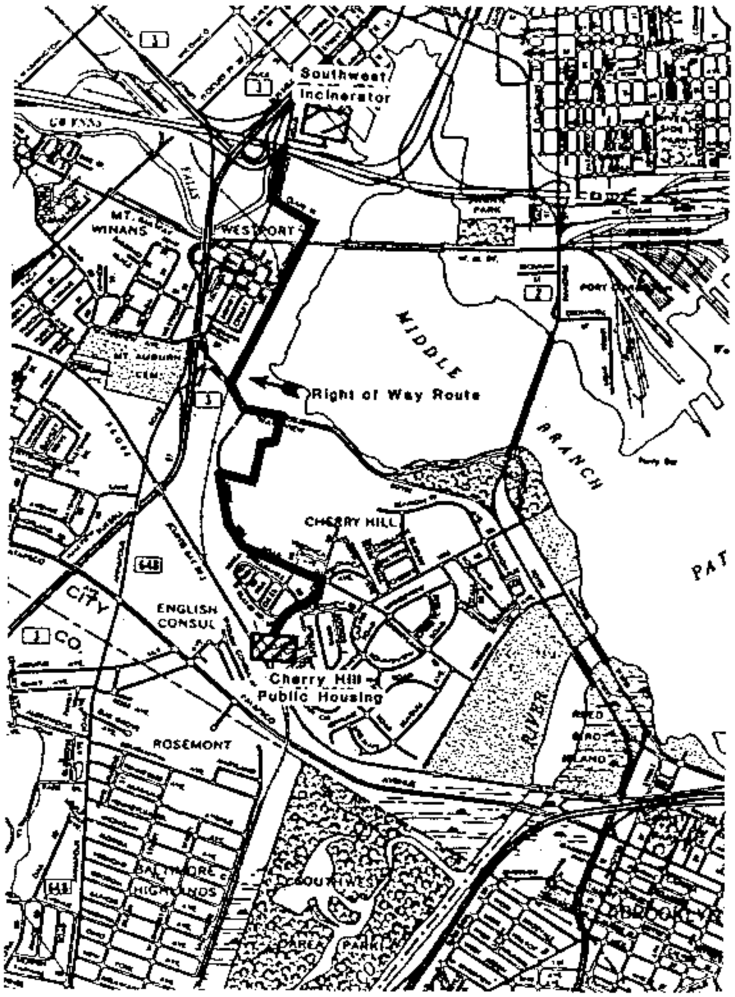



FIGURE 2-2

**THERMAL TRANSMISSION LINE**
**Proposed Right of Way**

SCALE: 1" = 1000'

The Baltimore District Heating project could only be considered feasible for development under two coincident conditions: 1) the utility operation produces a (positive) case flow sufficient to meet the expectations of the owner/operator, and 2) the utility operation can offer delivered energy costs (including costs of required end-user retrofit) competitive throughout the system life-cycle with conventional energy supply systems or schemes. If the first condition is met, potential owner/operators can be induced to develop the proposed district heating system. If the second condition is met, district heating can compete in the existing and/or future energy market, and customers can be attracted to the system.

In order to determine whether the Cherry Hill District Heating System could meet the revenue generation criteria for feasible development, a fuel equivalent net reveune analysis was conducted with appropriate district heating market and system data and prevailing and projected fuel/energy market data and run to predict estimated revenues for the district heating system in the two basic configurations proposed (cogeneration central plant and MSW Incinerator interconnect).

From the results of the analysis demonstrated significant profit potential over the total planning period. Thus, the Cherry Hill district heating system meets the first of the two economic conditions necessary for further development.

## Total End-User Energy Cost Analysis

In order to determine the competitiveness of district heating in current and projected energy markets, the total cost which an energy end-user pays to serve a given thermal demand was computed and compared. For existing conventional systems, this cost is the cost of the fuel required to deliver the specified demand (necessarily including a appropriate penalty to account for the significant inefficiency of individual building systems). For district heating, this total delivered energy cost includes the cost of district heating energy (district heating is essentially 100% efficient within the building envelop) and the levelized/amortized cost of retrofitting the individual end-user's structure to utilize district heating energy.

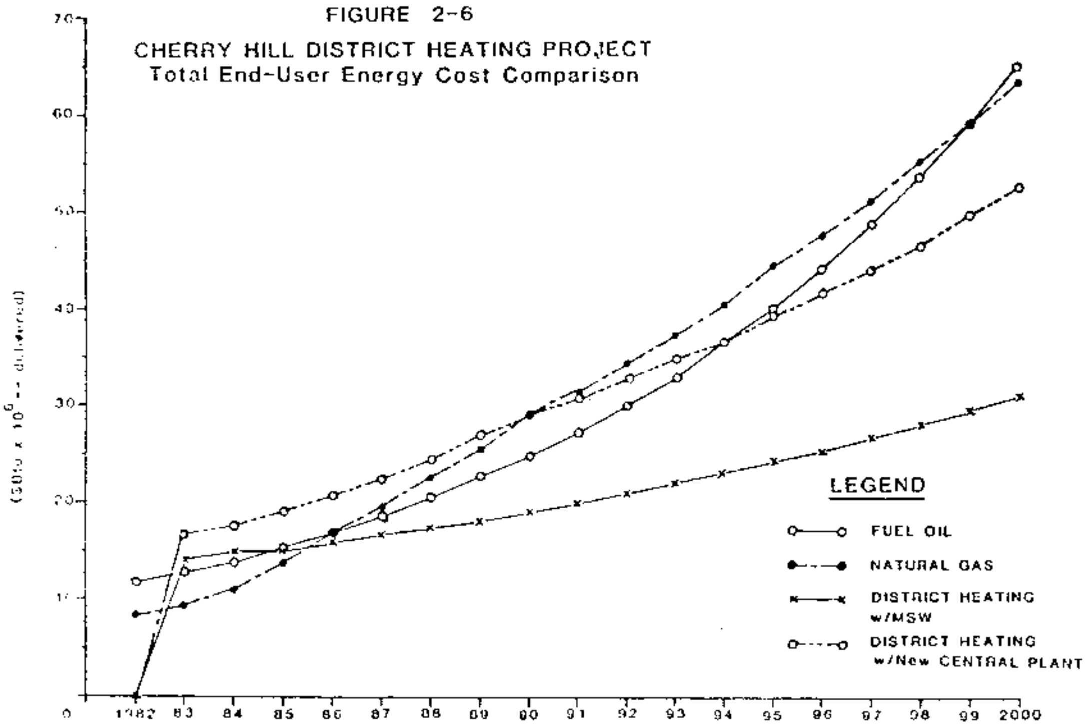



FIGURE 2-6
CHERRY HILL DISTRICT HEATING PROJECT
Total End-User Energy Cost Comparison

PROJECT DEVELOPMENT

The development of any project of this magnitude encounters its share of problems, or obstacles, which must be overcome to effect implementation. Many of these are common to any type of district heating project. For example: Will the economics work so that there is enough potential benefit to attract project participants? How can the capital costs be financed at the lowest rate? Is beneficial tax treatment available to a private sector owner? Will easement or franchise rights be obtainable for the optimum pipeline routing?

These obstacles are the type that can be solved or overcome by some hard work and creative thinking by experts in the appropriate field and examples for how to proceed are available from other successful projects. These and most other situations encountered in project development are not really "barriers" to implementation but are situations which must be addressed. A satisfactory solution (which does not have to be the "optimal" solution) must be found to allow a project to continue into construction and operation phases. The obstacles noted above and many others are of a type fairly common in most district heating projects and have been addressed in a variety of ways in the successful implementation of a variety of projects. Two particularly interesting items have developed in the course of implementing the Cherry Hill System which must be characterized as another type of obstacle; obstacles which are basic to the determination of participation in the project by one or more of the primary project participants. The first of these obstacles centers around the allocation of the "benefit pie" to the project participants and the second relates to the question of the thermal energy supplier become a regulated public utility.

Allocation of Benefits

Three parties must benefit from the Cherry Hill District Heating System: HABC; Baltimore RESCO; and the Subdivisions using the Southwest Facility for waste disposal. One major goal of the Project Team in developing the project structure is to provide each participant with a level of benefit which will convince them to participate in the project.

The form that the benefit will take is obvious for only two of the parties. Baltimore RESCO requires revenue from the sale of thermal energy sufficient to offset expenses and liabilities and, in addition, to provide a reasonable return on their capital investment. The Subdivisions expect a portion of the thermal energy sales revenues to be credited to them in the form of reduced waste disposal fees (similar in concept to how electric revenues are shared between the Subdivisions and Baltimore RESCO). The major difficulty related to the allocation of benefit to these two parties is in defining how much of the "benefit pie" is channeled to each. The allocation of benefit to HABC is a different matter.

In deciding to reconstruct the central heating system within Cherry Hills Homes and converting from steam to hot water, HABC is implementing a heating system which is more efficient and therefore less expensive to operate and maintain than was the old steam system. Economic analysis has shown that there is a significant lifecycle saving to be realized by implementing an oil-fired central hot water heating system when compared to the other alternatives: individual gas boilers in each building or continuation of the existing steam system. In addition, HABC could realize additional cost savings by contracting with Baltimore RESCO to guarantee the provision of energy to the Cherry Hill Homes. The utilization of refuse to produce energy, particularly in a co-generation mode, gives Baltimore RESCO some leeway in what it must charge per unit of energy. There was also leeway in how the price of energy must escalate over time. For example, Baltimore RESCO could offer HABC a discounted price for energy (compared to the current energy production costs) and also offer some discount from the escalation rate of the alternative fuel over the life of the contract. This purchase of thermal energy from Baltimore RESCO would allow HABC to shut down their central heating plant. In fact, the central heating plant could be sold or leased to Baltimore RESCO (who could use it as an emergency back-up heat source) thus providing additional revenue to HABC.

Under current HUD policy, HABC will benefit from the conversion to a new hot water district heating system because the Cherry Hill Homes project will use less energy with this system than with the old steam system. Total energy consumed will be lower, therefore both HUD and HABC will benefit from the cost savings. HABC will also benefit from reduced operation and maintenance costs for the new hot water heating system. Current HUD rules, however, do not allow local housing authorities to derive benefit from switching from high-cost fuel to lower cost fuel, in this case, from oil to refuse.

What this policy does, in this particular instance, is to direct benefits to certain parties since HABC can only receive a relatively small benefit (related to the operation of the central boiler facility and efficiencies inherent in the new distribution system). The major portion of the "benefit pie" must be divided between Baltimore RESCO and the Subdivisions. The situation for other customers is not the same, since savings from lower cost energy can be taken directly.

In the instance of the Cherry Hill System, this situation is not as detrimental to the implementation of the project as it may seem. Even though monetary benefit directly to HABC is marginal when compared to what it might be, indirect benefit is obtainable. One indirect benefit is the fact that HABC will not have to operate the central heating plant. In addition, the monetary benefit which could be expected to flow to HABC (from utilizing lower cost fuel) can be channeled to the City, in the form of reduced waste disposal fees at the Southwest Facility. In this way, all City residents share the benefit of the district heating system.

Utility Regulation

The second obstacle noted at the beginning of this section is that of the regulation of a source of thermal energy by the Public Service Commission of Maryland (PSC). The PSC regulates "all public service companies...engaged in or operating in the utility business in this state..." Preliminary legal opinion indicates that the decision concerning regulation as a "public service company," as found in the Maryland legislative history, relies heavily on the number of customers served by such a company.

To a company in the waste-to-energy business, as is Baltimore RESCO, PSC regulation is not desirable. The company's major activity is to dispose of solid waste by using it to produce energy for sale. Sale of electricity to a single customer, in this case BG&E (a regulated utility) presents no undue hardships and allows Baltimore RESCO to concentrate on disposing of wastes and producing energy. In trying to utilize the energy value of the waste more fully in a co-generation operating mode, Baltimore RESCO does not want to stray far from its primary business. A system serving a limited number of large institutional users fits perfectly in this scenario.

As noted earlier, the Cherry Hill System could include a variety of customers in addition to HABC. These customers include public schools, a hospital, private housing and a proposed industrial park. The preliminary legal opinion is that sale of thermal energy to two institutional users, i.e., HABC and public schools, would not open Baltimore RESCO to PSC regulation. Sale to private housing or an industrial park would virtually assure regulation.

In order to work within this strict interpretation of "public service company," the Project Team is structuring the Cherry Hill System to initially include only large institutional users, but with the ability to serve all identified Cherry Hill customers. Once the basic system is in place, the Project Team will attempt to secure an agreement with a regulated utility or a company willing to be in that role to utilize the thermal energy available to the system to serve the additional customers.

The logical entity for this venture would have been BG&E. However, BG&E corporate policy is to concentrate on providing gas and electric utility service and to end its steam business involvement. To this end, an agreement of sale was signed with Thermal Resources of Baltimore, Inc., (Thermal) for the downtown system. Discussions have been held with Thermal concerning sale of steam from the Southwest Facility for use in the downtown system. As Thermal has interest in expanding district heating in Baltimore, using the downtown system as a base, the possibility exists to enter into agreements with Thermal to develop the Hopkins/East Baltimore System or to expand the Cherry Hill System to the other identified customers in the area.

Other Community Benefits

In addition to the direct benefits of energy rate stabilization created as a result of implementing district heating in Baltimore, significant indirect but quantifiable benefits will also accrue to the city. As with any major capital construction project, district heating implementation would result in the generation of employment, in both the direct construction and manufacturing/support service sectors. In addition, energy dollars spent on district heating service would remain in the city rather than migrating away to the energy brokers/suppliers, and the increased capital retainage would generate additional trickle-down economic activity within the confines of the Baltimore community.

District heating system development can have a positive long-term impact on Baltimore area employment. The City will directly benefit from the jobs generated as a result of the construction of district heating systems since DHC system construction is labor intensive: it requires heavy equipment operators, welders, pipefitters and laborers. Given the labor force within the City, the majority of these jobs should go to Baltimore residents. While district heating will not solve unemployment, sustained construction activity can help alleviate labor surpluses in these skill areas.

DISTRICT HEATING PROJECT -- JOBS CREATION

| JOBS (Job-Years) | CHERRY HILL | HOPKINS EAST BALTIMORE | TOTAL |
|---|---|---|---|
| Construction (Direct) | 120 | 99 | 219 |
| Manufacturing | 308 | 255 | 563 |
| Service Sector | 360 | 297 | 657 |
| Totals | 788 | 651 | 1439 |

CAPITAL RETAINAGE IN THE COMMUNITY

DISTRICT HEATING VS. CONVENTIONAL FUELS/SYSTEMS

| PROJECT | DHC $ Retained | Compound Capital Retained | Existing System $Retained | Existing Systems Compound Capital Retained | Net Capital Retainage Benefit |
|---|---|---|---|---|---|
| CHERRY HILL | 4,262,923 | 12,788,768 | 1,072,246 | 3,216,738 | 9,572,030 |
| HOPKINS/EAST BALTIMORE | 4,670,143 | 14,010,428 | 1,543 106 | 4,629,318 | 9,381,110 |
| TOTALS | 8,933,066 | 26,799,196 | 2,615,352 | 7,846,056 | 18,953,140 |

SUMMARY

In developing the Cherry Hill District Heating System, the participants in the project have their own reasons and goals for wanting the project to proceed. Baltimore City saw an opportunity to provide a better quality of life in the Cherry Hill area by eliminating individual heat sources, providing stable-cost energy to a variety of customers in the area and promoting development using the district heating system. HABC saw a way to solve a heating problem in the Cherry Hill Homes complex and to eliminate the need to operate a boiler facility. In addition, HABC realized there was the availability to lower cost energy through negotiation of an initial energy price and escalation rate with Baltimore RESCO. Baltimore RESCO saw an opportunity to increase revenues to the Southwest Facility to operating in a co-generation mode and selling a higher percentage of the energy available from the combustion of solid waste. The Authority saw an opportunity to reduce tipping fees to the Subdivisions receiving waste disposal services at the Southwest Facility by negotiating a sharing of these increased revenues. The Project Team is attempting to develop a structure for the Cherry Hill District Heating System that meets these varied objectives. With the withdrawal of BG&E from district heating activities in Baltimore, the Project Team is also attempting to involve new private sector owner/operators in the district heating business.

# DISTRICT HEATING AND COOLING DEVELOPMENT IN PROVO, UTAH

## A CASE SUMMARY

Excerpt in part from a report by:

Garth Limburg
Provo City Power

Provo, Utah

## GENERAL INTRODUCTION

A District Heating and Cooling (DHC) system generates steam or hot water and in some cases chilled water from one or more central plants to provide multiple customers with energy transported through a piping distribution network. In most modern systems, water is heated or cooled at the central plant and pumped through underground pipes to buildings, where it is used for space heating and cooling, domestic hot water heating or low-temperature process heat.

U.S. Department of Energy (DOE) sponsored research on DHC systems using hot water transmission has shown that such systems can be effective in conserving energy and improving urban air quality. Benefits include stabilized energy prices to consumers, decreased dependence on scarce fuels, potential for integration of municipal waste energy recovery, and economic stimulus due to construction and growth in district heated/cooled areas. The U.S. Department of Housing and Urban Development (HUD) and DOE are encouraging local governments to consider the potential for district heating and cooling projects in their cities.

The City of Provo was selected in August 1981 to receive a grant administered by HUD under a cooperative agreement program targeted at DHC assessment in relation to Community Development programs. The City initially contracted with Trans Energy to assess the city-wide potential for district heating. During this assessment the City also received technical assistance from Argonne National Laboratory. Beginning early in 1983 the City initiated a detailed feasibility analysis of district heating. This analysis, conducted by Gilbert Commonwealth focused in part on the application of municipal waste-to-energy or resource recovery. The City then contracted with RESOURCE DEVELOPMENT ASSOCIATES, INC. (RDA) to refine the area-wide assessment and configure a small, implementable district heating system that could be constructed in the near term and later could be expanded to cover larger portions of the City. The period from December, 1983 through March, 1984 was then devoted to RDA's preliminary design of this early-start system, and the preparation of plans plans retrofit of selected end-users (including the preparation of Energy Audits and State Grant Applications). RDA was advised during the course of this work by the staffs of Provo City, Provo City Power, and the Mayor's office.

DISTRICT HEATING SERVICE AREAS

The first step in planning Provo's district heating and cooling system is an analysis of potential heating loads to be served. In order to make a preliminary determination of loads, RDA used its proprietary load analysis computer model to predict space heating and domestic water heating requirements on a block- by-block basis in the proposed service areas. This computer model requires input of building square footages on a block- by-block basis in order to predict annual consumption of thermal energy.

Provo used building square footage data collected by the Provo City Staff and Phase I Project Team as primary input into its computer model. Zone-by-zone loads for the 176 zones are included for review. The primary purpose of this analysis was to estimate an ultimate system peak load for the purpose of planning pipe sizes to the various service areas.

Development of a large, multi-sectoral district heating system is an ambitious undertaking. A community-scale energy system is developed over many years, beginning with the most pro- fitable service areas and ultimately expanding to cover signifi- cant portions of the City. Several thermal sources such as coal, municipal solid waste, and natural gas may provide heat to the system which will serve many commercial, institutional and resi- dential customers.

The problems associated with district heating systems development are in some ways similar to questions faced by other utilities concerned with meeting growth requirements. From a technical standpoint, however, they are compounded by the cost of installing over-capacity distribution systems, the physical bar- riers associated with adding additional capacity to existing underground distribution systems, and the incremental capacity gained from power plant retrofits.

Two major differences between fledging district heating sys- tems and other utilities are:

- Water and sewer utilities make extensive use of government involvement to plan and install facilities sized for future expansion. Thus the governments realize the necessity of underwriting expenditures made for future service requirements.
- Comparison of a district heating system with a mature electric utility is not appropriate since new district heating systems will grow at rates greater than the annual growth of electric utilities. This necessitates capital investment in distribution and plant capacity that cannot be covered immediately by operating revenue.

Due to the circumstances outlined above; in order to real- istically scale the project; and for the purpose of evaluating economic and financial feasibility, a system growth and phasing plan has been prepared.

The City of Provo's approach to district heating development will evolve in an orderly, phased fashion which optimizes front- end capital investment and parallels the expanding thermal mar- ket. Based on the load analysis, thermal supply evaluations, and preliminary cost and financial analysis, a phased district heat- ing system growth plan has been developed. The phases are:

Phase I -- Early Start/Initial System Development -Power Plant Modification, District Heating distribution and customer retrofit serving anchor customers.

Phase IB -- Upon demand, district heating service to nearby areas including University Villa Apartments, single family housing, Utal Tech, and adjacent low and moderate income areas.

Phase II -- District Heating Expansion to Provo Central Business District and surrounding environs.

Phase III -- Orderly System Growth.

As with any major capital-intensive project, the basic strategy for developing a viable district heating system is to "start small". This axiom is especially true for utility devel- opment so that the investment in infrastructure can be closely matched to the system's ability to produce revenue covering investment. Therefore, the Early Start/Initial System has been configured to focus on existing energy users in close proximity to existing thermal supply sources.

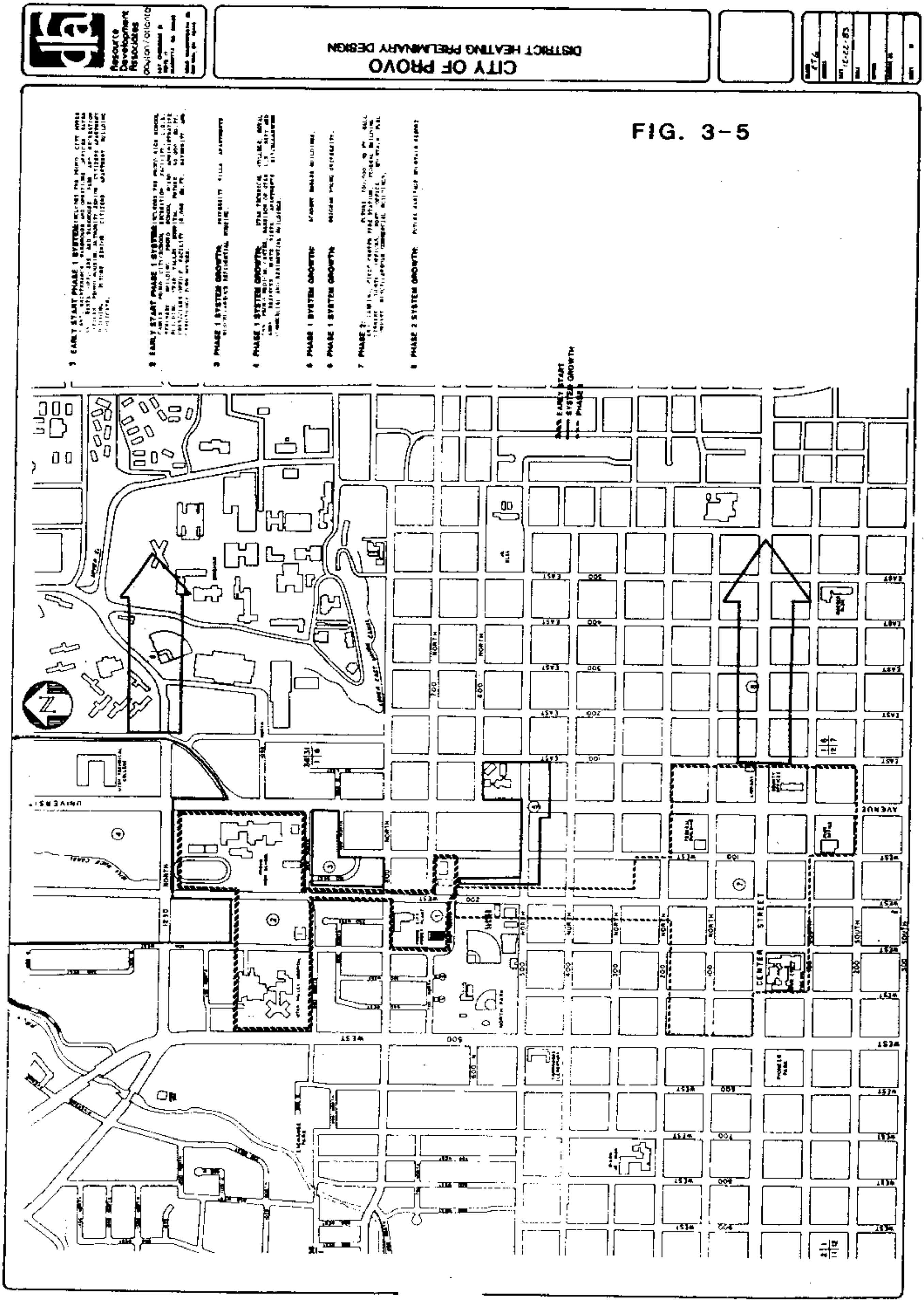



FIG. 3-5

## FIG. 3-6
## PROVO, UTAH
## District Heating Preliminary Design
## Initial System - Principal Customers

| BUILDINGS | SQUARE FEET | PEAK THERMAL LOAD | ANNUAL THERMAL THERMAL LOAD X $10^6$ BTU | HEATING SYSTEM TYPE |
|---|---|---|---|---|
| Recreation Center | 28,040 | 3,633,754 BTUH | 6,750 | Gas Fired Handling Units |
| High School | | | | |
| a) Main Building | 156,430 | 8,115,913 BTUH | 12,750 | Boiler With Steam Heat |
| b) D Wing | 28,800 | 992,215 BTUH | 1,566 | Steam Heat |
| c) Industrial Arts | 16,400 | 509,175 BTUH | 804 | Gas Fired Units |
| L.D.S. Seminary | 10,101 | 427,722 BTUH | 675 | Steam Heat |
| School Board Administrative Building | 15,100 | 680,000 BTUH | 1,050 | Hot Water |
| HUD Elderly Housing | 26,820 | 769,958 BTU | 1,200 | Hot Water |
| Hospital | 307,000 | 12,000,000 BTUH | 31,200 | Hot Water, Steam Heat Pump |
| Provo City Power Block | 33,310 | 1,143,669 BTUH | 1,800 | Steam Heat |

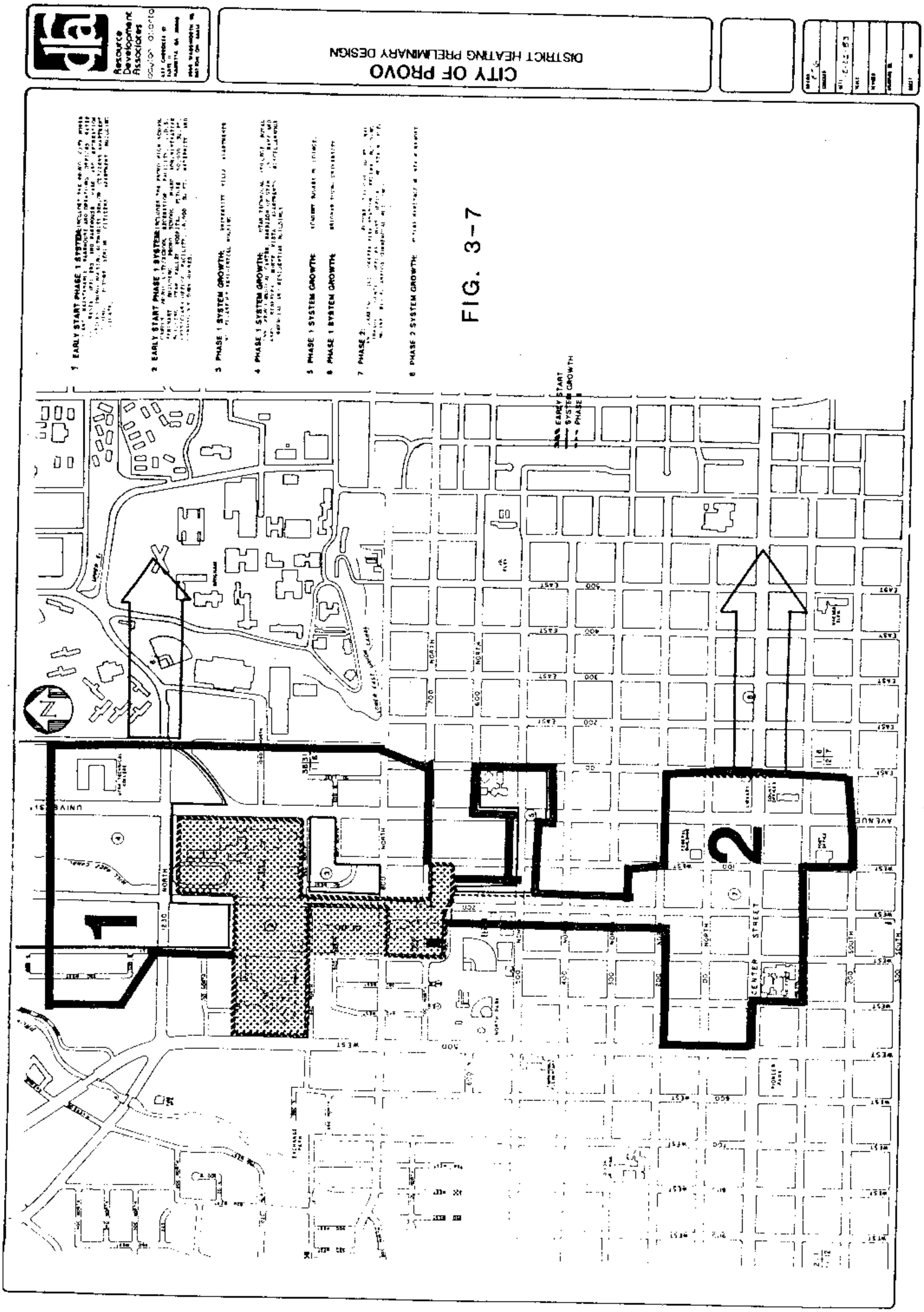

CITY OF PROVO
DISTRICT HEATING PRELIMINARY DESIGN
Resource Development Associates
FIG. 3-7
1 EARLY START PHASE 1 SYSTEM:
2 EARLY START PHASE 1 SYSTEM:
3 PHASE 1 SYSTEM GROWTH:
4 PHASE 1 SYSTEM GROWTH:
5 PHASE 1 SYSTEM GROWTH:
6 PHASE 1 SYSTEM GROWTH:
7 PHASE 2:
8 PHASE 2 SYSTEM GROWTH:
EARLY START
SYSTEM GROWTH
PHASE II
1
2
CENTER STREET
UNIVERSITY
AVENUE
PIONEER PARK
NORTH PARK
LOWER EAST UNION CANAL

FIGURE 3-8

DISTRICT HEATING SERVICE AREA
NEAR TERM GROWTH POTENTIAL

System Expansion Areas #1
(Incl. University Villa, Utah Tech and adjacent areas)

| Bldg. Sq. Ft. | Space Load | Water Load | Peak $10^3$ BTU/hr. | Total $10^6$ BTU |
|---|---|---|---|---|
| 664,000 | 161855 | 2332.39 | 7784.985 | 18,516.29 |

System Expansion Area #2
(Incl. Central Business District and Academy Square)

| Bldg. Sq. Ft. | Space Load | Water Load | Peak $10^3$ BTU/hr. | Total $10^6$ BTU |
|---|---|---|---|---|
| 1,310,800 | 73,680 | 5,676.54 | 35,440.08 | 79356.54 |

INITIAL/EARLY START SYSTEM PLAN

## POWER PLANT ADDITION

The first phase district heating system will require construction of a building to house a heat exchanger, control and pump, located adjacent to the existing power plant. High pressure steam will be piped from the 400 psig steam system in the power plant to the new district heating building, where it will be used in heat exchangers to produce hot water for the new district heating system. Once the high pressure steam is brought to the district heating building, it will be reduced in pressure through control valves and de-superheated for use in shell-and-tube heat exchanger equipment. Variable

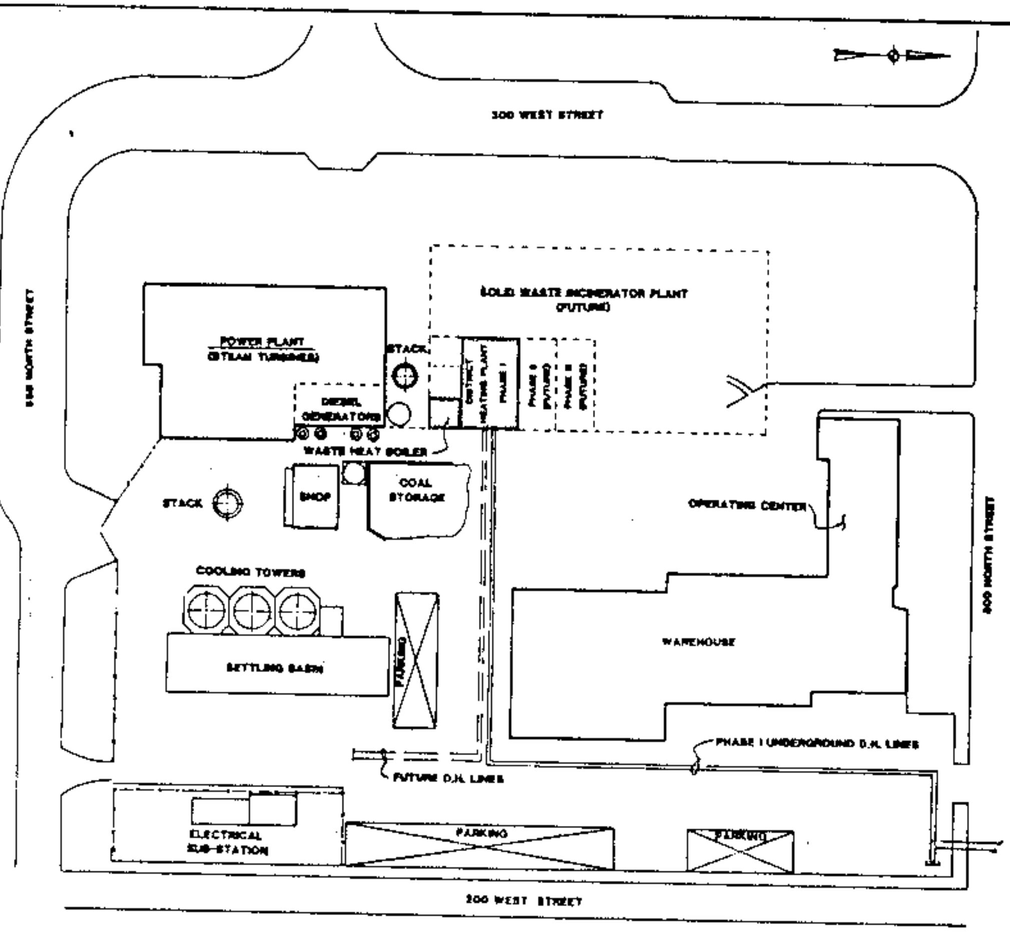
Resource Development Associates

# CITY OF PROVO

DISTRICT HEATING PRELIMINARY DESIGN

| | |
|---|---|
| | RTG |
| | DWW |
| | 2-10-84 |
| | 1"=400' |

FIG. 4-2




PROVO POWER PLANT SITE PLAN

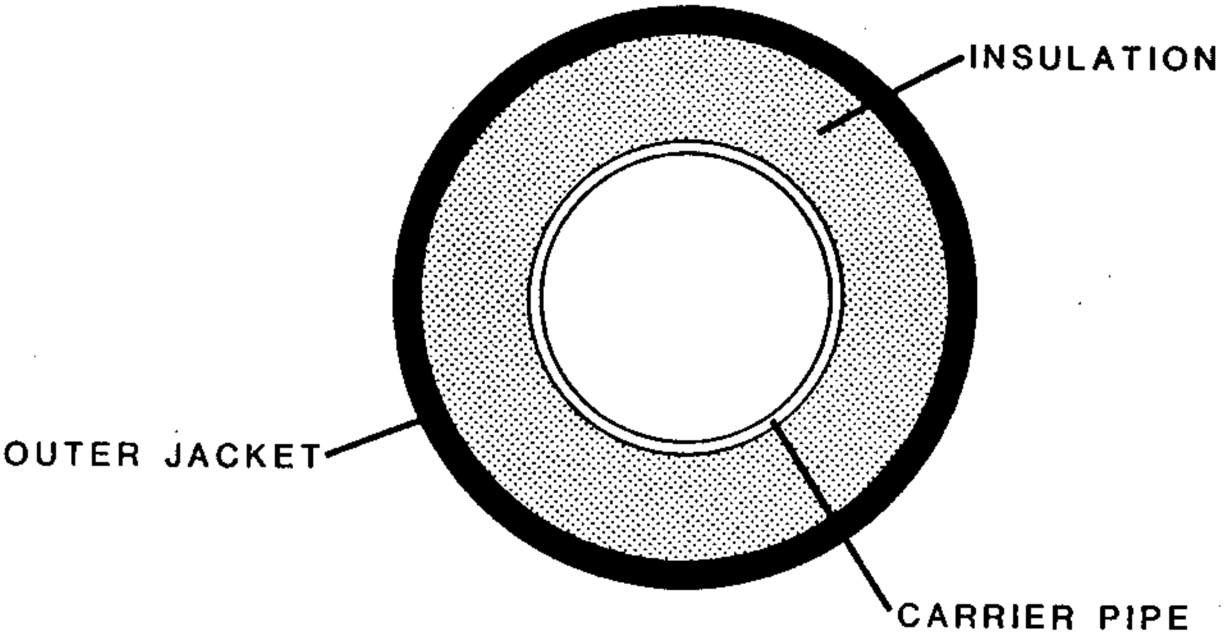
## DISTRICT HEATING UNDERGROUND PIPING SYSTEM

Piping systems consist of a carrier pipe, insulation, and an outer casing or jacket in contact with the insulation. The carrier pipe may be of any material that is suitable for the service. It is important that the carrier pipe be selected for the operating pressure and temperature as well as its compatibility with the fluid carried. Steel will be used in this case.

The jacket or outer casing may be PVC. The jacket will provide a positive water barrier to prevent moisture from entering the insulation as well as a watertight field joint.

The system requires provision for pipe movement within the insulation and casing, and the expansion may be absorbed by expansion joints or ball joints, or preferably with expansion loops or changes of direction of the piping. As part of the system design, proper anchorage must be provided to control movement.

When non-air-space systems are used for underground service, care must be exercised in the selection of materials for heat resistance and design consideration given to prevent the entrance of ground water.




After evaluation of many systems, RDA recommends a preinsulated piping system for use in the Provo project. Specifically, the piping system proposed is based on typical "bonded" piping systems and design practices which have been proven to result in installed costs 30-40 percent below other products and engineering practices.

Preinsulated underground piping systems have been used extensively in the United States and Europe over the past twenty-five years. The introduction of factory-made preinsulated pipe systems has resulted in cost effective installations for the transport of hot water, oil and many process fluids. Economies generally arise from simplified pipe installation techniques and reduced external pipe corrosion due to the integrity of the outer pipe casing.

BUILDING RETROFITS

The low temperature, low pressure system concept used in the Provo District Heating System will allow direct use of district heating water within customers' building systems. Retrofit of customers' buildings can take place through direct connection to existing hot water systems, modification of existing steam systems to use circulating hot water in lieu of low pressure steam, and replacement of existing direct fired heating equipment with hot water heating coils. In the case of the Provo system, all three types of building retrofits will be utilized. Figure 4-10 presents various design parameters for district heating customers in the initial service area.

Complete Energy Audit Technical Assistance Reports along with the required grant applications have been prepared and submitted for Provo City High School, Provo Recreation Center, and Utah Valley Hospital. Preliminary design approaches and cost estimates have also been prepared for these customers and the Seminary, School Board Administrative Offices, the Elderly Housing project and the Provo City Power block.

# FIG. 4-10

DESIGN PARAMETERS
INITIAL DISTRICT HEATING CUSTOMERS
PROVO, UTAH

| BUILDING | SQUARE FEET | CURRENT HEATING SYSTEM TYPE | RETROFIT COST | RETROFIT COST $/SF | PROJECTED ANNUAL ENERGY SALES X $10^6$ BTU | RETROFIT PLAN |
|---|---|---|---|---|---|---|
| Recreation Center | 28,040 | Gas Fired Handling Units | $ 91,000 | $3.24 | 6,750 | Add H.W. Coils |
| High School | 185,230 | Boiler with Steam Heat | $313,500 | $1.69 | 14,316 | Direct Use Hot Water in Existing Steam Radiators |
| Industrial Arts | 16,400 | Gas Fired Units | $ 29,230 | $1.78 | 804 | Add H. W. Coils |
| L.D.S. Seminary | 10,100 | Steam Heat | $ 13,510 | $1.33 | 675 | Direct Use Hot Water |
| School Board Administrative Building | 15,100 | Hot Water | $ 7,500 | $ .50 | 1,050 | Connect to Existing H. W. System |
| HUD Elderly Housing | 26,820 | Hot Water | $ 10,000 | --- | 1,200 | Connect to Existing H. W. System |
| Hospital | 307,000 | Hot Water, Steam, Heat Pumps | $160,030 | --- | 31,200 | Includes Small Gas Boiler, Connect via. Heat Exchanger |
| Provo City Power Block | 33,310 | Steam Heat | $ 83,250 | $2.50 | 1,800 | Direct Use Hot Water |

## ECONOMIC ANALYSIS

Economic assessment of the Provo District Heating System and subsequent growth phases requires analysis and evaluation from two positions - the PCP's (owner/operator) and the end-user's. From the PCP's perspective the project must produce revenues sufficient to meet the City's expectations and justify the investment and risk considering all accrued benefits.

In order to assess the economic feasibility of the District Heating Project, a Net Revenue Analysis is used to evaluate the project from the City's perspective. Debt service, fuel costs, and operating and maintenance costs are estimated according to standard engineering procedures, totaled and compared to total revenues to generate estimates of net revenue potential.

The bottom line in end-user decisions regarding connection to the district heating system will be the anticipated effect on Total End-User Thermal Cost. In some cases the initial capital outlay for connection and building retrofit will also influence a specific customer decision.

The Total End-User Energy Cost analysis model accepts capital and operating costs for a proposed DHC system and for reference (existing) end-user energy systems and predicts total delivered energy costs for the end-user. Results from this model are used in projecting feasibility of DHC penetration into existing energy/fuel markets and overall live-cycle energy costs and benefits to potential DHC customers.

In summary, Provo's district heating project could only be considered feasible for development under two coincident conditions: 1) the project produces a cash flow sufficient to meet the expectations of PCP, and 2) the DHC system can offer delivered energy costs (including costs of required end-user retrofit) competitive throughout the system life-cycle with conventional energy supply systems or schemes. If the first condition is met, the PCP will develop the proposed district heating system. If the second condition is met, district heating can compete in the existing and/or future energy market, and the customers can be attracted to the system.

## NET REVENUE ANALYSIS

The Net Revenue Analysis was used to test two cases or systems:

1. Initial District Heating System

2. Initial District Heating System plus Expansion Area #1

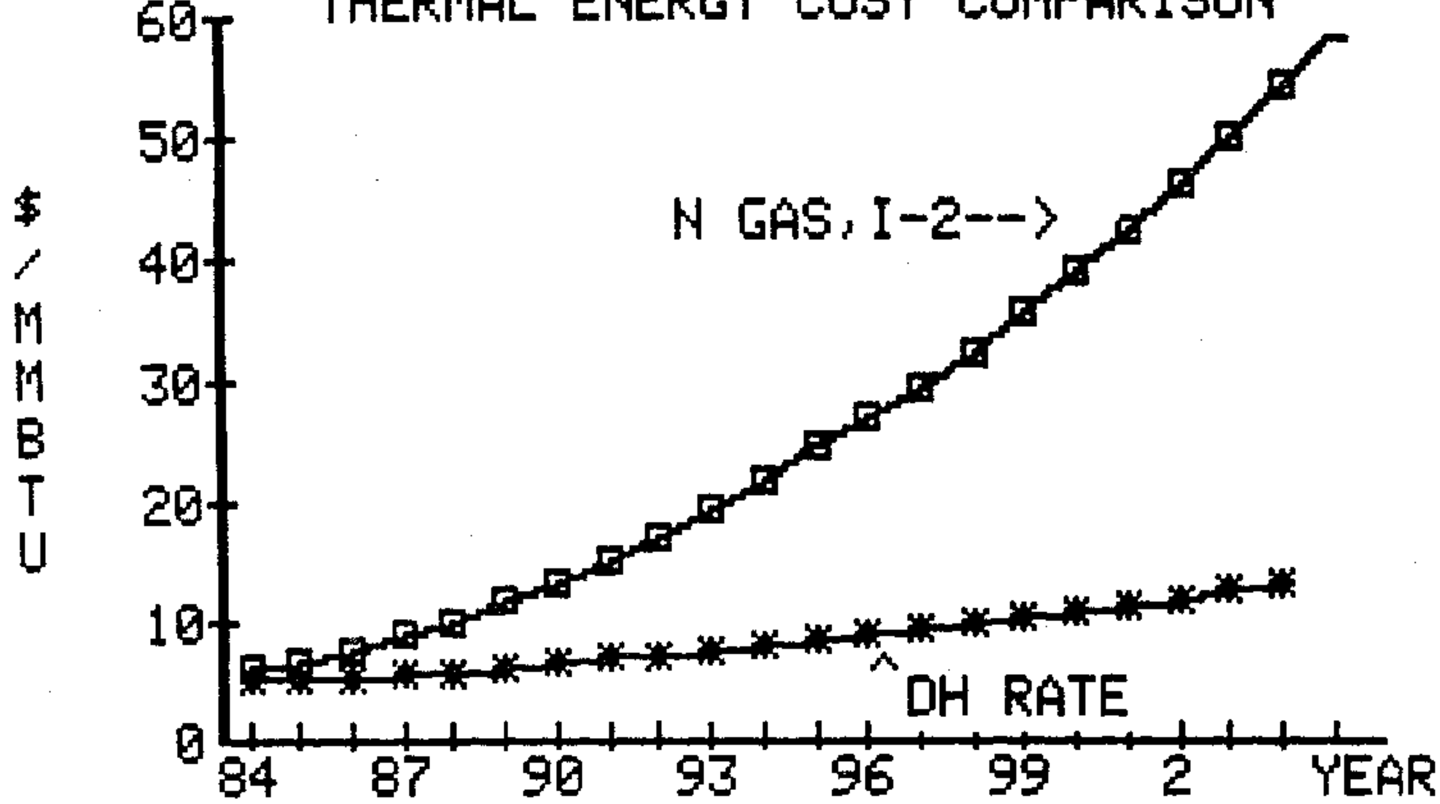
Using the most conservative assumptions, the Initial District Heating System produces positive net revenues by the ninth year while less rigid parameters result in positive revenues from year one. In all cases the entire principal is repaid and PCP has cumlative positive revenues of the twenty year analysis period. These revenues (without additional customers) range from a low of $742,000 to a high of $3,236,000 depending upon the assumed interest rate and level of CDBG prticipation. The addition of modest load (system expansion) improves the systems economics significantly.

## TOTAL END-USER THERMAL COST

The Figure on the following Page, illustrates and quantifies the substantial energy cost savings that will accrue to Provo District Heating customers over the project analysis period.

**PROVO INITIAL DH SYSTEM**

THERMAL ENERGY COST COMPARISON




INCLUDES ALL END USER RETROFITS
REFLECTS RELATIVE END USE EFFICIENCY

## CONCLUSIONS AND RECOMMENDATIONS

Following exhaustive analysis of district heating development, Provo has concluded:

1. Both an early start and a mature district heating system are technically feasible.

2. District heating, including the early start or initial system is economically and financially viable.

3. Provo City Power has the authority and capacity to own and successfully operate the District Heating System.

4. Substantial benefits will accrue to PCP which more than justify the relatively minimal risk. These benefits include:

    A. System Revenues
    B. Reinforcement of the Citys municipal power system in the Utah energy market
    C. Confirmation of the PCP power plant's operational role in the dispatch of both electricity and thermal energy
    D. Improving the future potential for cogeneration
    E. Providing the foundation for and improving the potential for resource recovery/waste-to-energy
    F. Protecting the PCP power plants dedicated air space

5. Substantial benefits will accrue to district heating customers and Provo citizens including:

    A. Lower thermal energy rates (see Figure 2-1)
    B. Lower energy price escalation
    C. Lower maintance cost
    D. Avoiding future boiler replacement
    E. Future cogeneration and waste-to-energy impact on electric prices

6. The early start district heating system can serve nearby multi-family housing and moderate income areas.

7. District heating and cogeneration represent significant energy conservation measures undertaken by PCP, and as such help insure continued shares of WAPPA hydroelectric allotment.

# DISTRICT HEATING AND COOLING DEVELOPMENT IN JAMESTOWN, NEW YORK

## A CASE SUMMARY

Excerpt in part from a report by:

Dr. Fred V. Strnisa
New York State Energy Research and Development Authority

Jamestown, New York

INTRODUCTION

District heating (DH) is the use of a central thermal source to provide heat to several users. The thermal source can cogenerate electricity and useful thermal energy or simply provide heat. The major energy benefits of DH are the fuel savings associated with increased fuel efficiencies and the ability to use coal or municipal solid waste to provide heat to many users. Air pollution is also reduced because of higher efficiency, better combustion and emission control obtainable at central stations, and the elimination of a number of dispersed low-level chimneys.

The objective of the New York State Energy Research and Development Authority (NYSERDA) district heating program is to stimulate implementation of DH in New York. The Energy Authority has initiated a series of site-specific projects to achieve this objective. Subject to go no-go decisions at critical points, each site is anticipated to move from conception to implementation in a three-phase program. The objectives of the phases are:

Phase 1: accomplish the engineering, economic, financial and marketing analysis in sufficient detail to secure local financial support for subsequent phases;

Phase 2: perform the detailed engineering, marketing and financial analysis required to finance the project; and

Phase 3: finance, construct and operate the DH systems.

NYSERDA has completed several Phase 1 studies (1,2,3). Jamestown has moved to the second phase. Based on our success in Jamestown, we issued a competitive solicitation seeking sites for additional Phase 1 and Phase 2 studies across the State. To date, sites in Buffalo, Rockville Centre, Rochester and New York City have been contracted.

Jamestown recently received bids for the first stage of system development, which will ultimately lead to the system described in the case study. Jamestown, like other cities implementing district heating, is successfully moving forward for a variety of reasons. Quality technical analysis and engineering provided the foundation in the first phase of the analysis, this analysis demonstrated that a project was feasible.

Jamestown, with the support of NYSERDA, was able to then have the "staying power" to structure a project that was initially doable and ultimately expandable into the industrial area and central business district.

The keys to this project have been the availablity of the municipally owned utility, the active support of the Mayor of Jamestown, Steven Carlson, the NYSERDA grant, and the staged approach to development.

FACTORS INFLUENCING THE COST OF DISTRICT HEATING

One of the most important characteristics of DH systems is their site-specific nature. As a result of previous efforts (4,5), NYSERDA has identified a number of factors, all of which to varying degrees, affect the cost of DH. The factors include: solid fuels, cogeneration, inexpensive thermal source, inexpensive piping systems, utilization factors, customer connections and ownership. Following is a brief discussion of the factors. Case studies are presented in subsequent sections to serve as examples of how these factors impact specific sites.

Solid Fuel

A coal or municipal solid waste fired DH system has definite advantages over one fueled by oil or gas. The advantage of coal was demonstrated in the James town and Ravenswood studies. In Jamestown the cost of delivered coal is approximately $1.60 per million Btu compared to $5.68 for natural gas in

January 1984. Coal prices are expected to escalate at a lower rate than oil or gas prices (6). The conversion of Ravenswood Unit 3 to coal would have reduced the 30-year levelized cost of the DH system by 40% when compared to an oil-fired system.

### Cogeneration

With the advent of the Public Utility Regulatory Policies Act of 1978, a qualified cogenerator can sell electricity to a utility and be paid at the utility's "avoided cost." In areas with high electric rates, the cogenerated electricity may be more valuable for use on-site. Both electric and thermal sales can both provide a positive revenue stream to the DH system. In the case of retrofitting an existing electric generation plant to provide thermal energy, replacement electricity costs are charged against the DH system to compensate for reduced electrical output. In both the Jamestown and Ravenswood cases this electric penalty was found to be a significant portion of the DH customers' costs.

### Thermal Source

An inexpensive thermal source is required for a successful DH system. In spite of the electric penalty associated with the retrofit of electric power plants, retrofits can provide a relatively inexpensive source of thermal energy for a DH system. The major reasons are that capital-intensive facilities (e.g., boilers, fuel storage and fuel handling equipment) are already in place, and the DH system uses waste heat. For both the Jamestown and Ravenswood cases, the power plant retrofit provided an inexpensive thermal source.

## Transmission and Distribution Systems

The transmission and distribution system can account for 50 to 75 percent of new DH system's cost. The temperature and pressure of the delivered thermal energy affects the cost of pipe. Steam or high-temperature/pressure hot water pipe is more expensive than the low-temperature/pressure pipe. The distance from the source to the load affects the cost of materials and installation. Underground obstacles such as electric, water and sewer lines increase installation costs.

In the Ravenswood case the installed cost of a two-pipe, 350° F, 205 psig hot water system was almost $2000 per foot, due in large part to congestion under the streets. A successful DH system will seek to minimize piping system costs by providing minimum temperature/pressure service consistent with customer needs, locating the source near the load, and avoiding underground obstacles.

## High Utilization Factor

A high utilization factor reduces the time required to pay off the capital investment. A good DH site would have a large year-round thermal load consisting of institutional or industrial users and a cold climate. District cooling during the summer might improve the load factor, but this is generally limited to larger customers. For residential buildings with fewer than 40 units, electric-driven air conditioning appears to be more economical than absorption cooling (3).

## Customer Connection

From the customer's point of view, the prospective hook-up cost and resulting payback period dominate the decision to join the system. New construction and hot water heated buildings present few problems. By using existing end-user equipment, steam heated buildings can be converted to hot water at a relatively low cost. Conversion of electric-resistance buildings to DH can be prohibitively expensive.

### Ownership

In some cases DH economics can be affected by the type of ownership. Municipal or non-profit ownership can result in lower thermal costs because of available low-cost financing and exemptions from property and sales taxes. A municipal or non-profit owner may also require a lower return on investment than a private owner. For example, a municipality that wants to provide the lowest cost energy possible to its corporate and private citizens may find a project to be feasible if the project's revenues are sufficient, over the life of the project, to pay all operating costs, build up reserves required to ensure long-term operating viability, and repay the bonds used to finance the district heating system. However, a private business might find the same project unfeasible because either it could not achieve the desired return on capital, or it could not achieve it quickly enough.

## JAMESTOWN, NEW YORK

NYSERDA is working currently with the City of Jamestown, its Board of Public Utilities, and the consulting firm of Burns and Roe, Inc. in the second phase of a district heating implementation program. The City of Jamestown has a distinct advantage over many other localities because it already has in place a municipal electric utility which is experienced in providing utility services and is responsive to local needs.

The results of the Phase 2 analysis to date (7) indicate that a system with an initial load of approximately 13.5 MWt can be constructed with an investment of approximately $3,000,000. The cost of converting the customers has been estimated to be approximately $1,000,000. The system will deliver thermal energy at a rate which is competitive with existing fuels and will allow almost all customers to recover their conversion costs in three years or less.

## Thermal Source

The Jamestown Board of Public Utilities Steele Street Station will provide hot water for the system. The power station burns coal and has two operating turbine generators (Units 5 and 6). Cooling towers are used to cool the circulating water. The towers are connected to ponds which are connected to the Chadakoin River. The heat available from Unit 5 is small compared to that from Unit 6 and, therefore, only modifications to Unit 6 were considered. Unit 6 is a 25 MWe, 15-stage condensing unit.

To select the optimum method for converting Unit 6 to a cogeneration district heating plant, the following criteria were considered: maximum thermal efficiency at lowest capital and operating cost; reliable supply of electricity and heat; operating flexibility to independently vary the electrical and thermal output; thermodynamic and mechanical constraints; and space availability and structural design limitations.

Steam will be extracted from the blanked-off eleventh stage of the Unit 6 turbine for use in a new district heating condenser for loads up to 7 MWt. For loads above 7 MWt, additional steam is taken from the auxiliary steam header and used in the existing Unit 6 auxiliary heat exchanger that will be arranged in series with the new district heating condenser. Modifications to the turbine are not required since the redistribution of extraction flows is minimal. All existing feedwater heaters remain in service without modification. Table 1 presents the estimated installed capital costs for the district heating retrofit at the Steele Street Plant. The costs are based on manufacturers' quotes and from plant drawings determining pipe lengths and equipment locations.

## Transmission System

The piping system is designed as a two pipe closed system with all pumps, treatment facilities, and the expansion tank located at the Steele Street Station. The system will have a design operating pressure of approximately 270 psi, with pumps sized for a total design discharge pressure of 140 psi. The piping is sized for a maximum velocity of eight feet per second, based on peak load supply temperature of 250° F and return temperature of 160° F. The prefabricated conduit system will consist of a carbon steel carrier pipe, polyurethane insulation, polyethylene casing, and a leak detection system.

Sidewalk installation is generally more cost effective than burial beneath streets. Installing the conduit below the sidewalks allows shallow excavation, eliminates shoring, involves less expensive surface removal and

TABLE 1 JAMESTOWN POWER PLANT RETROFIT COSTS (1984 Dollars)

| ITEM | COSTS |
|---|---|
| DH Heat Exchangers | $ 60,000 |
| DH Pumps | 41,000 |
| Piping and Valves | 334,000 |
| Removal/Relocation of Existing Equipment | 7,000 |
| Heat Tank | 25,000 |
| SUBTOTAL | 467,000 |
| Contingency | 70,000 |
| Engineering & Construction Management | 88,000 |
| TOTAL | $ 625,000 |

TABLE 2 JAMESTOWN DISTRICT HEATING PIPING SYSTEM COST (1983 Dollars)

| ITEM | COSTS |
|---|---|
| Transmission Piping | $1,658,000 |
| Customer Connections | 238,000 |
| Engineering, Construction Management, Contingency | 474,000 |
| TOTAL | $2,370,000 |

replacement, encounters fewer interferences with other utilities and causes less disruption of vehicular traffic. Investigation of the existing utilities in Jamestown determined that the most cost effective installation would be a combination of street and sidewalk installation with most of the piping beneath the sidewalks.

The cost estimates for the recommended transmission route are shown in Table 2.

## Customer Costs

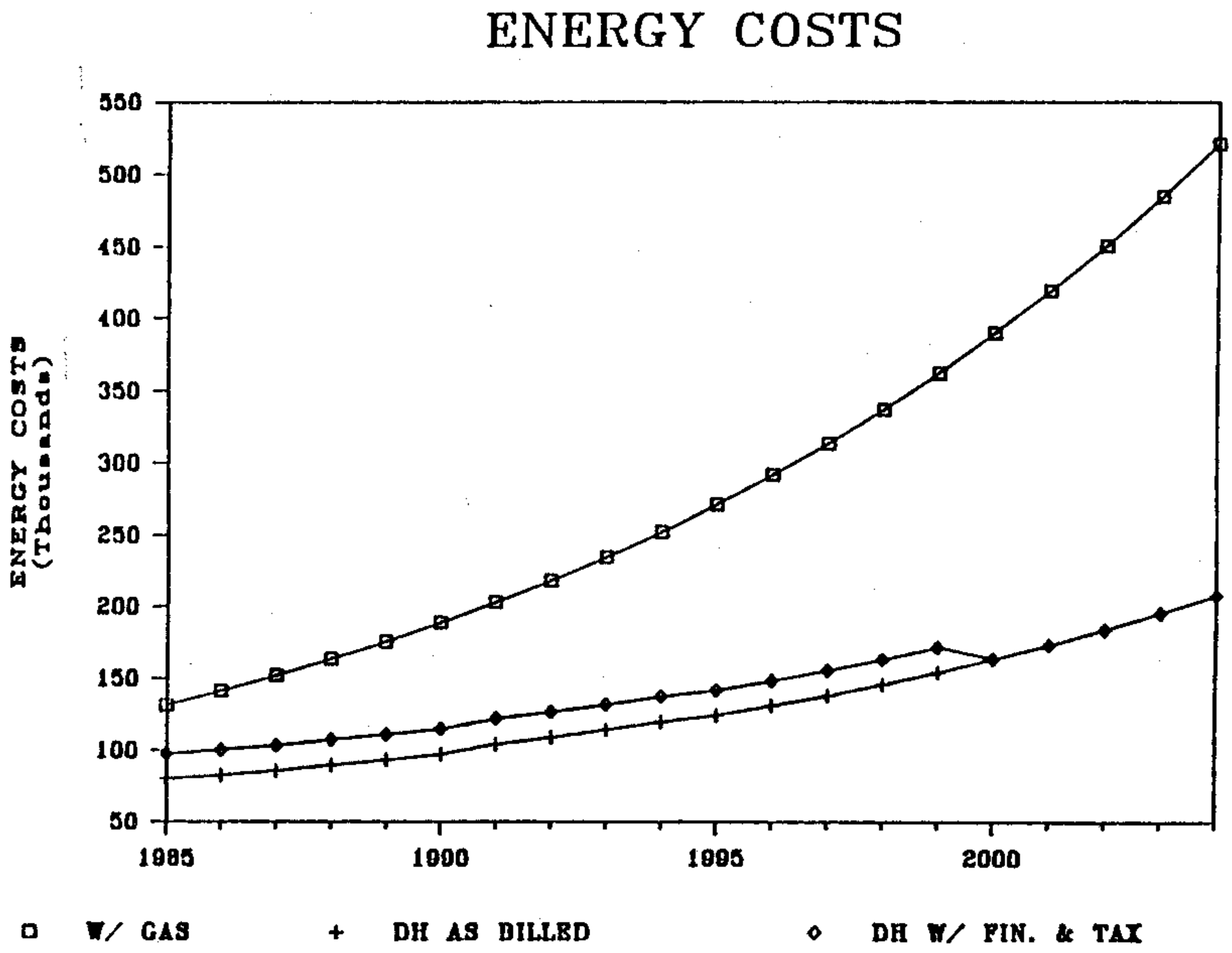
A core area heat load of approximately 13.5 MWt provides the minimum load necessary to implement an economic system. Building retrofit designs and cost estimates have been developed for 19 buildings in the core area which comprise over 90% of the heat load. Most of the prospective customers' heating systems are steam. The conversion of the terminal heating units to hot water constitutes a significant portion of the overall conversion work. The total cost estimate for converting the 19 buildings to hot water district heat is $954,000. This estimate includes direct cost for all material, equipment and labor, contractor's overhead and profit, engineering fees and a contingency.

A 20 year economic analysis was performed for each of the 19 customers to determine their annual cash flow and payback. Total estimated retrofit costs were estimated in 1985 dollars and an annual loan payment was determined based on the percentage of the retrofit cost financed and the financing terms of a 9% loan for 15 years for each customer. The customer's average cost of gas ($5.68 per million Btu from National Fuel Gas Distribution Corp. for January 1984) was escalated at 7.5% per year. The customer's annual energy costs with district heating were determined based on current consumption, current boiler efficiency, potential end use energy savings, and the calculated unit cost of district heat. Potential end use energy savings for present steam users are achieved by eliminating trap losses and decreasing line losses. The customer's yearly tax effects were based on tax rate, depreciation, interest payments, energy costs and the expensing deduction. The IRS allows a one-time $5000 expensing deduction and an accelerated five year-depreciation on heating equipment.

All of the annual costs for energy, financing and taxes were used to determine the annual savings for the customer switching to district heating. Two payback periods were calculated, a traditional payback period assuming no financing and a payback with financing, where payback is achieved with the accumulated savings exceed the unpaid principal plus any cash investment.

In all cases, the payback for the 19 core customers is expected to be three years or less with a positive cash flow in the first year. An example of the cost of heat for a typical large customer is shown in Figure 1. The Figure shows the customer's cost of DH, with and without financing, compared to the cost of continuing with his existing system.

FIGURE 1




Source: Reference 7

System Economic Analysis

The economic analysis was based on ownership by the Jamestown Board of Public Utilities. The required revenue approach was used to determine the necessary customer DH rates. The total system costs were calculated and compared with tht total quantity of heat sold to determine the minimum district heating rate charged to the customer. The total system costs are comprised of fixed expenses, operating expenses, replacement electricity and gross receipt taxes. The capital costs include all direct and indirect costs associated with the power plant retrofit and the piping systems.

The annual carrying charges for the district heating investment were calculated based on 100% debt financing with bond rates of 7% and 9.75%. A floating fixed bond is being considered to finance the project which could result in a 7% bond rate. The utility pays no income and property taxes, and its insurance rate is 0.5%. The analysis was conducted for a 30-year book life.

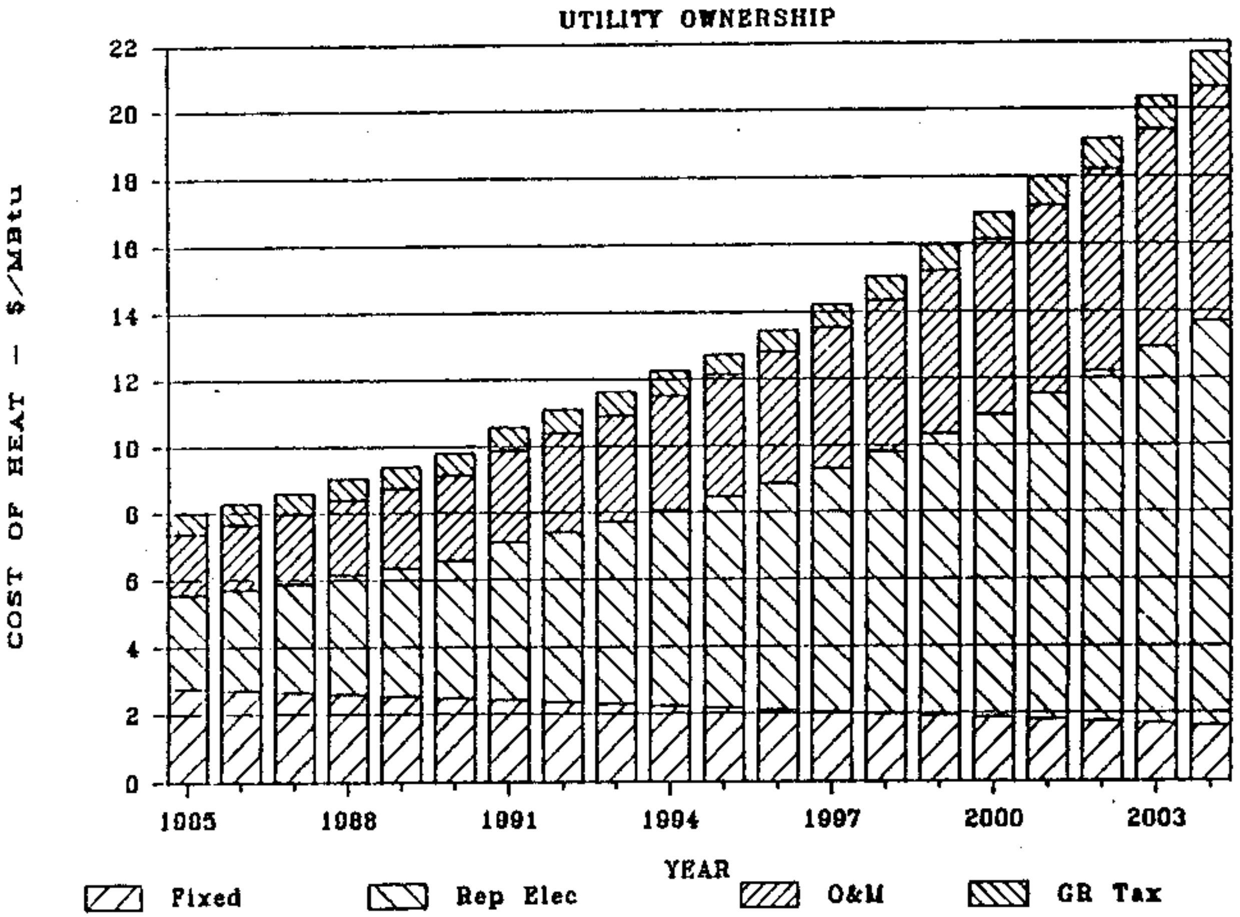
The replacement electricity costs are charged against the district heating system to compensate for the reduction in electrical output of the station caused by the district heating retrofit. The replacement electricity costs are $42/MWh. Pumping costs are calculated using $30/MWh. Power costs are escalated at 7.5.% per year. Operating and maintenance manpower for the system is estimated to cost $50,000 per man-year in 1984 dollars, including overhead and benefits, escalated at 7.5% per year. Operating and maintenance material costs are estimated to be equal to 3% of the capital costs of the heat source and 1% of the capital costs of piping on an annual basis, escalated at 7.5% annually. Steam costs are calculated using $2.27 per thousand pounds in 1984, escalated at 1% per year. The quantities of replacement electricity, pumping power and steam were determined from the load duration curve.

Figure 2 shows the cost of district heat graphically for a $3,000,000 capital investment in the power plant and piping (1984 dollars), financed through 7% bonds. The estimated first-year cost to the DH customer is $8.00 per million Btu delivered. This compares favorably to the $5.68 paid for gas in January 1984 when the inefficiencies of the customers' existing thermal system is considered (i.e., annual boiler efficiency and losses from steam lines and traps). At a 70% annual system efficiency, the DH rate is competitive with gas. The spread between the two will grow in future years as the escalation rate for gas exceeds that for coal.

Several factors contribute to the attractive costs for Jamestown. These include: an existing coal-fired facility that will cogenerate electricity through a low-cost power plant retrofit; municipal ownership resulting in attractive bond rates; high annual utilization due to several large customers with good load factors and cold winters (7900 heating degree days); minimum underground obstacles; and low cost retrofit of steam customers.

FIGURE 2

# DISTRICT HEATING FOR JAMESTOWN N.Y.

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RETROFIT OF RAVENSWOOD UNIT NO. 3

One of the early NYSERDA efforts (3) was to investigate the technical and economic aspects of retrofitting a utility power plant in New York City, Ravenswood Unit No. 3, to extract 300 million Btu per hour during the peak heating season for heating a neighborhood in Astoria. The neighborhood is composed primarily of two-and three-family houses, small and large apartment buildings, and some commercial and industrial loads. The system was designed to produce hot water at 350°F and 205 psig at a maximum flow rate of 6600 gpm. These conditions were compatible with Ravenswood Unit No. 3, would enable service to steam heated buildings, and would enable absorption air conditioning.

The 30-year levelized cost of the DH system was found to be lower than for continued use of individual heating plants. However, an incentive would have been required to attract users to the system due to higher DH costs in the early years. Consequently, the project did not proceed to the second phase.

The major factors adversely affecting the DH economics included: insufficient load to justify the capital expense; high transmission and distribution costs, primarily due to the distance from the power plant to the load and congestion under the streets; poor utilization factor due to the relatively mild winters (4800 heating degree days) and a load consisting of buildings too small to utilize district cooling; and use of oil for fuel.

DUNKIRK, NEW YORK

One of the projects currently being considered for Phase 1 support by NYSERDA is in Dunkirk, New York. The proposed source for the district heating system is Niagara Mohawk Power Corporation's coal-fired Dunkirk station. Because the potential thermal load is relatively small, the capital expense required to extract high-quality heat from the plant is not warranted. Instead, the warm condenser cooling water would be taken directly from the outfall of the plant and used as the heat source for heat pumps installed in the buildings. Approximately 800 gal/hour of water at a minimum temperature of 50° F would be pumped through a 10-inch distribution main from the plant to the various buildings and then returned to Lake Erie. During the summer, cool lake water would be pumped from a different location to provide cooling water to the heat pumps for air conditioning. Five thousand feet of uninsulated PVC pipe will be used to transport and distribute low-temperature and low-pressure water from the plant to the buildings. The transmission path would be through unpaved terrain, and no underground obstacles are expected.

The district heating load would include space heat and domestic hot water for a new harbor front development consisting of office, retail and hotel space and domestic hot water for an existing electrically heated 100 unit apartment building. The Dunkirk climate is similar to Jamestown (7900 heating degree days). The annual load to be served by the district heating system is 8.0 10(9) Btu/yr. The capital cost for the pumps and the installed distribution system is estimated to be $140,000. The cost of converting the 100-unit apartment building and the incremental cost of installing the water source heat pump system versus conventional gas boilers and air conditioning units in the harbor front development project is estimated to be $55,000. The total incremental capital cost of the district heating/cooling project is estimated to be $195,000. The estimated energy cost-savings during the first year is $45,000 resulting in a simple payback of 4.3 years.

Although the size of the load and incremental cost of the heat pump system are uncertain, on balance we are interested in evaluating the site because it has the following attractive features: low-cost thermal source; low-cost transmission and distribution system using low-temperature/pressure water, inexpensive pipe, and unpaved terrain with no underground obstacles; a large fraction of the load from new buildings resulting in minimum user connection costs; 7900 heating degree days and air conditioning for higher utilization factors.

## RESOURCES REQUIRED TO IDENTIFY AND DEVELOP DISTRICT HEATING PROJECTS

Jamestown is successfully moving through the second phase of the three-phase NYSERDA program to the point where project construction could begin this summer. In 1983, NYSERDA issued a competitive solicitation for Phase 1 and Phase 2 studies which resulted in 23 responses. Six Phase 1 projects have been contracted with the following organizations: Buffalo Development Downtown, Inc., National Energy Capital Corp., New York City, New York State Urban Development Corp., City of Rochester, and Village of Rockville Centre. All the sites have the characteristics of cost effective DH described in this paper, to one degree or another such that we consider implementation to be likely. Many promising sites were not funded, primarily due to lack of resources.

The Energy Authority has found that a considerable amount of site-specific engineering, marketing and economic analysis is required to interest developers and investors. However, once feasibility has been demonstrated, local support increases dramatically. In order to reap the energy and environmental benefits of district heating , a cooperative federal, state and local effort to identify and initiate individual idstrict heating projects is w arranted. The DOE/HUD 28 Cities Program and its subsequent phases paved the way for DH development in the U.S. It is recommended that the Federal government continue the initiative it began with the 28 Cities Program by continuing its support of Phase 1 and Phase 2 efforts.

We have accomplished a great deal, but we are not yet at the point where the private sector alone will carry DH from conception to completion.

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# DISTRICT HEATING AND COOLING DEVELOPMENT IN LAWRENCE, MASSACHUSETTS

## A CASE SUMMARY

Excerpt in part from a report by:

Kevin Clement
Energy Coordinator

Lawrence, Massachusetts

## Introduction

Lawrence, Massachusetts was developed in the early 19th century as a planned industrial community. The driving force behind its founding and early economic growth was the utilization of the most modern textile processing technologies and facilities, together with the availability of water power from the Merrimack River. Within two decades the community grew into one of the most vibrant industrial centers in the northeast.

About a hundred years after its incorporation in 1847, however, Lawrence began to decline as a textile manufacturing center. By the late 1950's many of the firms left the city for cheaper labor and newer facilities elsewhere in the country. This coupled with a variety of other problems which plague America's older cities, led to a marked decline in Lawrence's physical and social character.

In the mid 1970's the city began to experience a rebirth. It's economic base was improving. Lawrence was once again becoming a desirable place in which to live, work and recreate.

The Community District Heating System which is the subject of this paper, is one of the city's major efforts to spur Lawrence's revitalization. It has already made significant contributions to the city's economic well being and promises even more benefits for the future as it is expanded. Much of the district heating project's development and history is reminiscent of the city's founding. Now, as over a century ago, an entrepreneurial spirit and a utilization of state-of-the-art energy technologies are greatly in evidence. The city is on the verge of again becoming the host and beneficiary of a planned downtown energy system.

This paper will outline the city's historical background, including the utilization of District Heating in Arlington Mills, one of the earliest and largest textile mill complexes in the city. It will describe how components of this earlier system have actually been incorporated into the current Resource Recovery and District Heating project. The present system will be discussed in detail. Not only will its technical aspects be covered but also some of the institutional underpinnings. Plans for its expansion in the immediate future will also be presented.

## Lawrence Historical Background

Lawrence is located 28 miles north of Boston and about 2 miles south of the New Hampshire border. Originally hailed as the "New City of the Merrimack", Lawrence was founded in 1845 by a group of enterprising manufacturers and financiers who were incorporated as the Essex Company. The purpose of the company was to harness the water power of the Merrimack River and utilize that power for manufacturing.

It was not long before the envisioned manufacturing center became a reality. Within the first few years of its existence, Lawrence witnessed the construction of numerous mills and extensive housing, commercial structures, and public buildings to meet the needs of the great influx of people. During these formative years, the city population swelled to more than 100,000 living within the small 6 1/2 square miles city limits. Residents came from over 50 foreign countries and spoke over thirty different languages, earning the city the name "immigrant city" which today continues to be appropriate.

Between 1880 -1920, Lawrence moved to the position of largest worsted textile producer in the world with the huge steam powered mills of the

Pacific, Arlington, and American Woolen Companies lining the river. The city had also become a center for the manufacture of paper and paper-making machinery. Large numbers of immigrants from many nations supplied the labor necessary to operate the booming industries. After World War II, the production of textiles in Lawrence greatly declined. Today, most of the mills have been converted to other manufacturing uses.

## Arlington Mills Complex

The Arlington Mills Complex (as shown in Figure 1) was established during the post-Civil War period of textile mill development in Lawrence. The city was already an important textile manufacturing center and the Arlington Mills contributed to and prospered with the city's economic successes. By 1925 the site contained approximately 23 structures, most of them devoted to worsted wool and cotton manufacturing. It became one of the city's largest industrial districts and was then, as it is today, surrounded by neighborhoods of worker's homes. With its rich industrial and social legacy, the Arlington Mills complex has been designated a historic district. It contains a variety of old facilities which are still in use today but in effect are historical treasures.

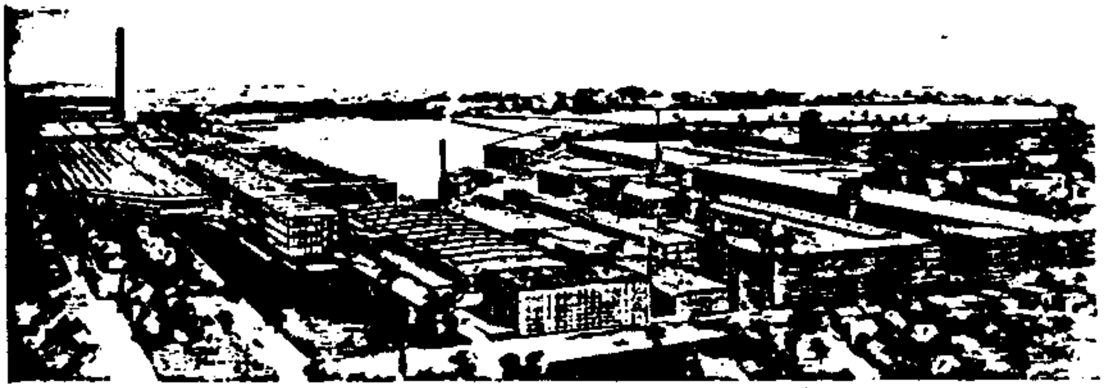

FIGURE 1
ARLINGTON MILLS COMPLEX
(Circa 1920)

A significant number of the mill buildings in the Arlington Complex depended on steam for their heating and processing needs. The steam was originally supplied to the buildings from two boiler houses. This steam production and piping network was the original Lawrence District Heating System.

In 1906 a new powerhouse was built and contained fourteen handfed coal fired boilers. The addition of primitive turbine generators upgraded the structures in 1916. Numerous changes were made during the next six decades. The Powerhouse currently operates with three oil/natural gas fired boilers and five turbine generator sets, and supplies all of the process and heating requirements and part of the electrical needs of the buildings in the Arlington Mills complex. The Powerhouse can be seen in the upper left hand corner of Figure 1.

The 75 year old Powerhouse was purchased in 1982 by Refuse Fuels, the private developer of the current Resource Recovery Project and Community District Heating System, and totally refurnished. It now is one of the major components of the new District Heating System, and will be described in further detail later in the paper. The Arlington Mills complex also comprises a major portion of the market for the system. In effect the Powerhouse and the Complex itself form the cornerstone for the community wide District Heating System presently under development.

The early history of the Complex and Powerhouse therefore constitutes the history of District Heating in Lawrence.

## The Lawrence Community District Heating System

Under a comprehensive energy and economic development program developed for the city by the Department of Energy and New England Innovation Group in 1980, Lawrence began pursuing several major energy conservation projects. One of these was a resource recovery/district heating system as proposed by Refuse Fuels. A grant award from HUD enabled the city to help Refuse Fuels assess both the adequacy of the available central heating sources for the proposed system as well as the suitability of an adequate market for the thermal energy which could be produced. It also enabled the city to play a role in the system's planning.

During the system's early development process, a strong complementary between public and private interests was achieved. Leadership by Lawrence city officials and the effort of Refuse Fuels, resulted in all necessary commitments and clearances for the $90 million project by early 1982. Ground breaking ceremonies for the largest part of the system were held on June 15, 1982.

The total project, most frequently referred to as the Lawrence Resource Recovery Facility, all are in Lawrence proper (see Figure 2).

### Resource Recovery Plant

A new central Resource Recovery plant located in Haverhill, a city bordering Lawrence, was completed in March 1984 (see Figure 3). It is designed to process approximately 1300 tons of municipal and commercial refuse per day.

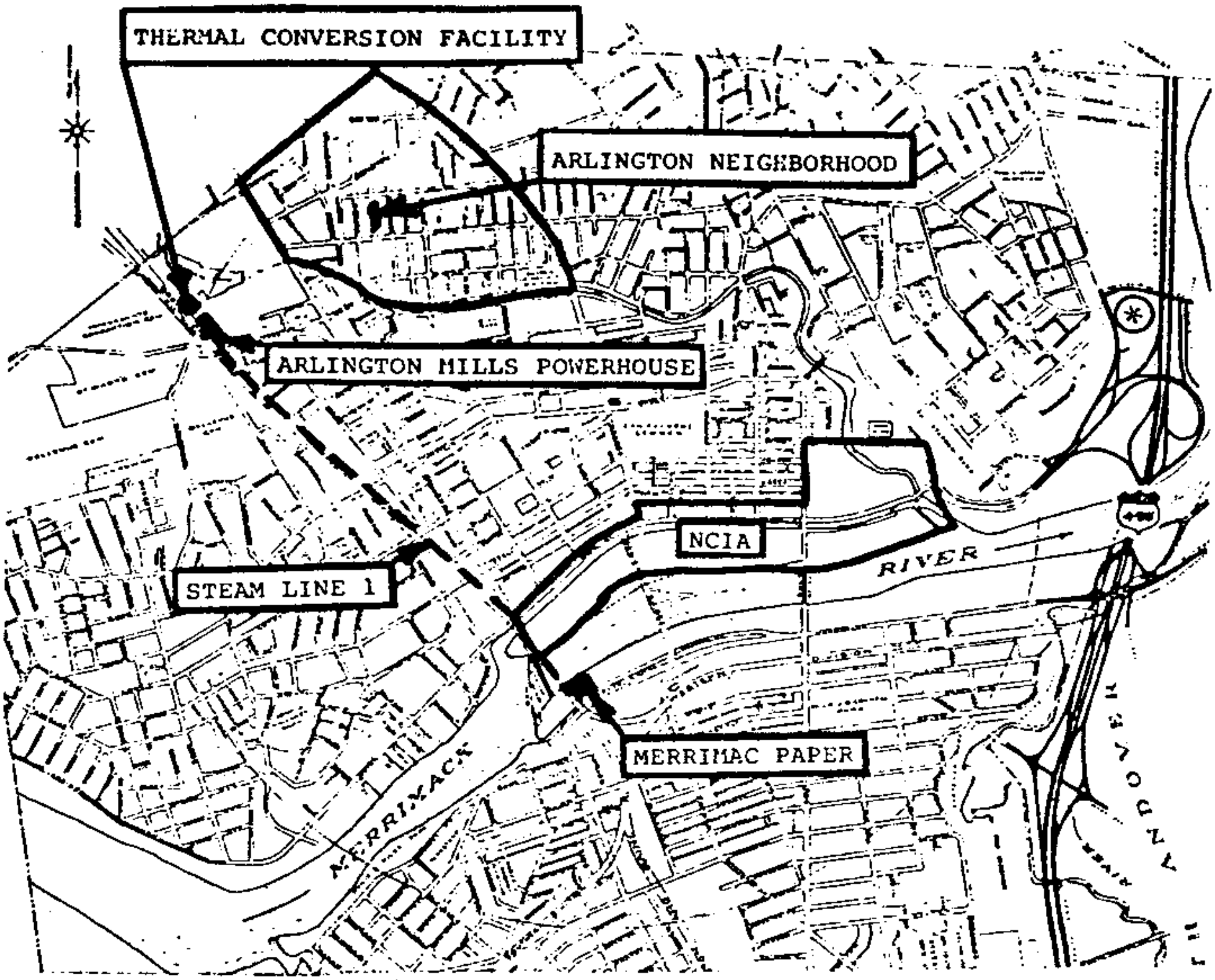


FIGURE 2
LAWRENCE COMMUNITY DISTRICT HEATING COMPONENTS

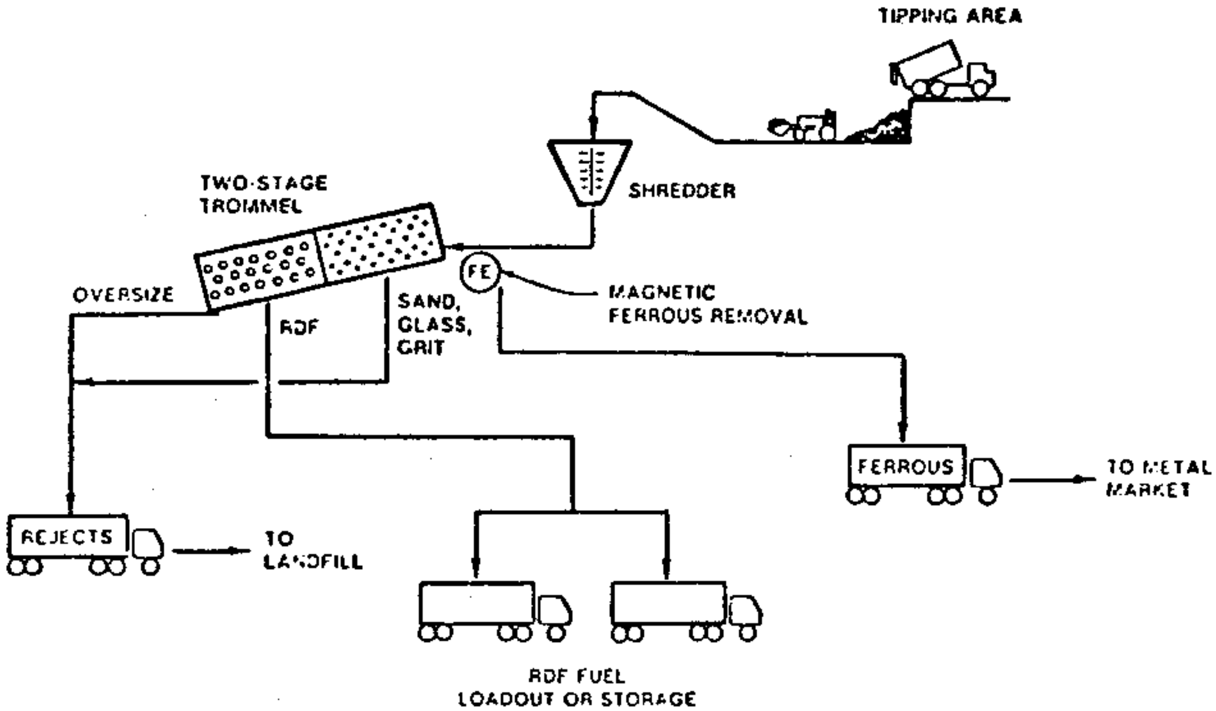


FIGURE 3
RESOURCE RECOVERY FACILITY
PROCESS SYSTEM FLOW SCHEMATIC
HAVERHILL, MASSACHUSETTS

At the facility, the solid waste is dumped, inspected and then shredded with ferrous metals and non-combustible material removed. The shredded product of the entire process is actually a refuse derived fuel or RDF having a heat content of approximately 5500 Btu per lb.

Thermal Conversion Facility

RDF produced at the Resource Recovery plant is loaded onto trucks for delivery to a new Thermal Conversion facility in Lawrence to be completed the summer of 1984 (see Figure 4). Located at the Arlington Mills Complex and adjacent to the Arlington Mills Powerhouse, the Conversion Facility essentially burns the fuel in a dedicated Babcock and Wilcox boiler, heating the water to create steam at 250,000 lbs. per hour, 750° F and 600 psig.

Arlington Mills Powerhouse

The steam from the Conversion Facility is fed to the adjacent Arlington Mills Powerhouse where it powers up to five General Electric turbine generators, cogenerating steam and electricity. Three oil/natural gas fired boilers used for decades to power General Electric turbines have been rehabilitated and will remain active for back up and peaking purposes for the RDF boiler.

Some of the electricity generated at the Powerhouse is used on site as well as sold to existing customers within the Arlington Mills Complex. With the RDF boiler on line, New England Power Company (NEP) will purchase surplus electricity produced at the Powerhouse based on 85% of the avoided cost rate of NEP.

Steam Line 1

Some steam generated at the Powerhouse is used to supply the existing customers in the Arlington Mills Complex. A new high pressure steam line, 1.5 miles long, has been installed to carry steam from the Powerhouse to Merrimac Paper Co., Inc., a manufacturer of paper in Lawrence since 1865. The steam supplied will provide for all of the company's process and heating needs, eliminating the expense of operating an in-house oil fired boiler. In addition to Merrimac Paper, the steam line will supply two Lawrence Housing Authority public housing complexes totaling 324 units. A separate pipe along the same route will carry condensate back to the Powerhouse for reuse.

Future Plans for the Lawrence System

Using the new refuse derived fuel boiler will produce a substantial surplus of process and heating steam. The City and Refuse Fuels have been interested in providing district heating service to additional sections of the community, thereby contributing to local revitalization efforts.

A District Heating Feasibility Report is scheduled to be completed in July, 1984. Its principal components include evaluations on extending a high pressure steam line into the North Canal Industrial Area (NCIA) to service industrial clients with heating and/or process steam and a hot water district

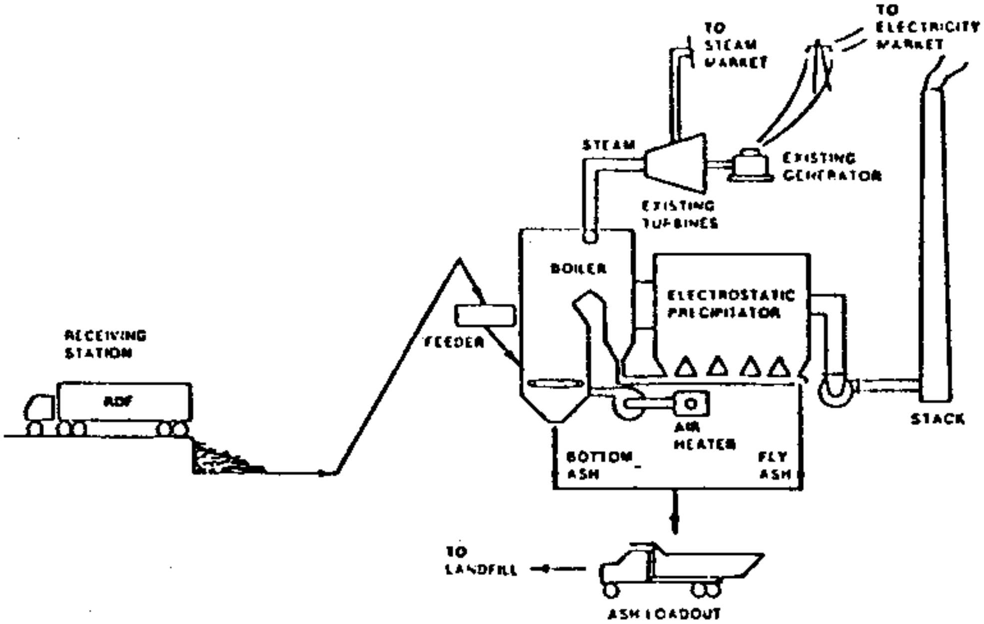


FIGURE 4
THERMAL CONVERSION FACILITY
PROCESS SYSTEM FLOW SCHEMATIC
LAWRENCE, MASSACHUSETTS

heating system for a residential neighborhood known as the Arlington Neighborhood. The NCIA steam line would be constructed with materials similar to Steam Line 1. The DHS for the Arlington Neighborhood will obtain heat from one of the three existing condensing turbines. The turbine will be retrofitted in order to operate under higher exhaust temperature and pressure conditions. The exhaust steam will be converted to hot water via a heat exchanger and will be capable of servicing the entire neighborhood, i.e., a population in excess of 6,000 persons or 2,400 dwelling units.

Preliminary results are encouraging. Conclusions at this point would however, be premature. If certain factors such as the availability of a suitable financing package can be resolved, the expansion should be able to proceed. If accomplished, it will not only allow for significant energy savings in Lawrence through the adoption of advanced resource recovery and district heating technologies, but also assist in the renaissance of two of the city's most distressed sections.

Summary

District heating development in Lawrence has progressed because of a combination of past experience and present needs and opportunities. It has been greatly facilitated by the drive and vision of public officials and private developers. An effective public/private partnership concerned with helping to bolster the local economy through improved energy use patterns has emerged.

The Resource Recovery and Community District Heating System and the energy savings and new local investments which it represents, has always been held to be an important local technological innovation. It is also however beginning to offer a set of local economic and community development tools which should not be overlooked. Other older communities like Lawrence may also wish to conceptualize of district heating as a means to an end --economic revitalization, rather than an end in itself.

The project in Lawrence demonstrates how Federal participation in project planning and packaging (PHASE I and II) can stimulate private sector development. District heating is often an identified element of comprehensive energy planning. However, the capital intensive nature of the project and the amount of analysis necessary generally discourage communities from pursuing this option. Lawrence was fortunate to have interested a private developer -Resource Fuels- in the project, and the timing of the HUD/DOE assessments was opportune. It is probable that other similar opportunities have been missed due to the non-cyclical nature of assessment finding.)

Lawrence demonstrates the leveraging effect of federal investment. It also demonstrates how private-public partnership work to mutual advantage in major infrastructure projects. The side benefit to HUD in this development is the hook up of the public housing complexes. This connection will reduce and stabilize the cost long turn operation of then units to the government.